

SECTION 15542

FUEL-FIRED RADIANT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes gas-fired infrared and high-intensity radiant heaters.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
  - 1. Design Calculations: Calculate requirements for selecting seismic restraints.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Field Quality-Control Test Reports: From Contractor.
- D. Operation and Maintenance Data: For fuel-fired radiant heaters to include in emergency, operation, and maintenance manuals.
- E. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.
- B. Source Limitations: Obtain fuel-fired radiant heaters through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, profiles, and dimensional requirements of fuel-fired radiant heaters and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchanger of fuel-fired radiant heater that fails in materials or workmanship within specified warranty period.
- B. Warranty Period: Five years from date of Substantial Completion.

1.06 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Burner Igniters: One hot-surface burner igniter for each style of gas-fired radiant heater furnished.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.02 TUBULAR INFRARED HEATERS

- A. Available Manufacturers:
  - 1. Gas-Fired Products Inc.; Space-Ray Div.
  - 2. Reznor/Thomas & Betts.
  - 3. Solaronics, Inc.
- B. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.6, "Gas-Fired Infrared Heaters."
  - 1. AGA Approval: Designed and certified by and bearing label of American Gas Association.
  - 2. Type of Gas: Designed and built to burn natural gas with characteristics same as those of gas available at Project site.
- C. Combustion Tubing: Aluminized steel with high-emissivity, high-temperature, corrosion-resistant external finish.
- D. Tubing Connections: Stainless-steel couplings or flared joints with stainless-steel draw bolts.

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- E. Reflector: Polished aluminum, 97 percent minimum reflectivity, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Provide for rotating reflector or heater around a horizontal axis for minimum 30-degree (0.52-radian) tilt from vertical.
  - 1. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees (0.52 radians) from vertical.
  - 2. Include hanger kit.
- F. Burner Safety Controls:
  - 1. Gas Control Valve: Single-stage, regulated redundant 24-V ac gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
  - 2. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.
  - 3. Control Panel Interlock: Stops burner if panel is open.
  - 4. Indicator Lights: Burner-on indicator light.
- G. Burner and Emitter Type: Gravity-vented power burner, with the following features:
  - 1. Emitter Tube: Aluminized-steel tubing with sight glass for burner and pilot flame observation.
  - 2. Venting: Connector at exit end of emitter tubing for vent-pipe connection.
    - a. Vent Terminal: Vertical.
  - 3. Burner/Ignition: Power gas burner with electronic spark and electronic flame safety.

## 2.03 TEMPERATURE CONTROL

- A. Sensors, Components, and Wiring: Specified in Division 15 Section "HVAC Instrumentation and Controls."
- B. Thermostat: Single-stage, 24-V ac, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Examine roughing-in for radiant heater piping systems to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install radiant heaters level and plumb.
- B. Install and connect gas-fired radiant heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.
- C. Suspended Units: Suspend from substrate using chain hanger kits and building attachments.
  - 1. Restrain the unit to resist code-required horizontal acceleration. Seismic restraints are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Gas Piping: Comply with applicable requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service. Provide AGA-approved flexible units.
- D. Connect vents according to Division 15 Section "Breechings, Chimneys, and Stacks."
- E. Electrical: Comply with applicable requirements in Division 16 Sections.
  - 1. Install electrical devices furnished with heaters but not specified to be factory mounted.
- F. Ground equipment according to Division 16 Section "Grounding and Bonding."
  - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections.
  - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 2. Verify bearing lubrication.
  - 3. Verify proper motor rotation.
  - 4. Test Reports: Prepare a written report to record the following:

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- a. Test procedures used.
- b. Test results that comply with requirements.
- c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.05 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain fuel-fired radiant heaters. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15542



SECTION 15626

ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes packaged, air-cooled, electric-motor-driven, rotary-screw water chillers with the following features:
  - 1. Motor controller.
  - 2. Microprocessor-based controls complying with ASHRAE 135.
- B. Related Sections include the following:
  - 1. Division 15 Section "Refrigerant Monitoring and Safety Equipment" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.03 DEFINITIONS

- A. EER: Energy-efficiency ratio.
- B. IPLV: Integrated part-load value.

1.04 SUBMITTALS

- A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections, and elevations, and unit isolation. Include the following:
  - 1. Assembled unit dimensions.
  - 2. Operating weight and load distribution.
  - 3. Required clearances for maintenance and operation.
  - 4. Size and location of piping and wiring connections.
  - 5. Vibration Isolation Calculations and Details: Signed and sealed by a qualified professional engineer.
    - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

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- b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
    - 6. Wiring Diagrams: Power, signal, and control wiring.
  - C. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:
    - 1. Structural supports.
    - 2. Piping roughing-in requirements.
    - 3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
    - 4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
  - D. Certificates: For certification required in "Quality Assurance" Article.
  - E. Manufacturer Seismic Qualification Certification: Submit certification that water chillers, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." Include the following:
    - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
    - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
    - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  - F. Source quality-control test reports.
  - G. Startup service reports.
  - H. Operation and Maintenance Data: For each water chiller to include in emergency, operation and maintenance manual.
  - I. Warranties: Special warranties specified in this Section.
- 1.05 QUALITY ASSURANCE
- A. ARI Certification: Signed by manufacturer certifying compliance with requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."



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- B. ASHRAE Certification: Signed by manufacturer certifying compliance with ASHRAE 15 for safety code for mechanical refrigeration. Comply with ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.
  - C. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - D. Comply with NFPA 70.
  - E. Comply with UL 1995.
- 1.06 DELIVERY, STORAGE, AND HANDLING
- A. Ship water chillers from the factory fully charged with refrigerant or nitrogen.
- 1.07 COORDINATION
- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- 1.08 WARRANTY
- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Carrier; a United Technologies Company.
  - 2. Dunham-Bush.
  - 3. McQuay International.
  - 4. Trane Company (The).
  - 5. YORK International Corporation.

### 2.02 PACKAGED WATER CHILLERS

- A. Description: Factory-assembled and -tested water chiller complete with casing, compressor, heat exchanger, condenser coils and fans, and controls integrated with compressor operation.
  - 1. Casing: Weatherproof, constructed of hot-dip galvanized steel with factory-painted finish.
  - 2. Fans: Propeller type, statically and dynamically balanced, with vertical air discharge for high efficiency and low sound; located in its own compartment to eliminate cross flow of

condenser air during fan cycling; and equipped with heavy-gage, weather-protected fan guard.

3. Fan Motor: Direct drive, weatherproof, with bearings permanently lubricated, and having built-in current- and thermal-overload protection.

- B. Fabricate water chiller mounting frame and attachment to the pressure vessel with reinforcement strong enough to resist water chiller movement during a seismic event when the water chiller mounting frame is anchored to the building structure.

## 2.03 COMPRESSORS

- A. Description: Positive displacement, oil injected with direct-drive, hermetically sealed motor.
  1. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
  2. Rotors: Single Twin screw.
- B. Capacity Control: Hydraulically operated, modulating or stepped sliding valve to maintain chilled-water temperature set point without hunting within throttling range. Throttling range shall be from 100 to 10 percent of full load.
- C. Oil Lubrication System: Positive-displacement submersible pump with heater, oil filter, and sight glass.
- D. Refrigerant and Oil: HCFC-22.
- E. Refrigerant Compatibility: Seals, O-rings, motor windings, and internal water chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
- F. Refrigerant Circuit: Two independent circuits. Each circuit shall include an electronic expansion valve, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

## 2.04 HEAT EXCHANGERS

- A. Remote Evaporator:
  1. Description: Shell-and-tube design, ASME labeled.
  2. Shell Material: Carbon steel.
  3. Tube Construction: Individually replaceable, expanded into tube sheets.
    - a. Material: Copper.
    - b. Internal Finish: Enhanced.
  4. Water Box: Standard, with design working pressure of 300 psig (2070 kPa), and having grooved mechanical-joint coupling water-nozzle connections with a thermistor-type temperature sensor factory installed in each nozzle.

- B. Air-Cooled Condenser: Copper tubes with mechanically bonded aluminum fins, integral subcooling circuit, leak tested at 450 psig (3105 kPa).
  - 1. Safety and Operating Options: Low-ambient controls for operation down to 25°F (4°C) ambient.

## 2.05 INSULATION

- A. Cold Surfaces: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type II, for sheet materials.
  - 1. Thickness: 3/4 inch (19 mm).
  - 2. Adhesive: As recommended by insulation manufacturer.
  - 3. Factory apply insulation over entire surfaces of water chiller components.
    - a. Apply adhesive to 100 percent of insulation contact surface.
    - b. Seal seams and joints.
    - c. After adhesive has fully cured, apply two coats of protective coating to insulation.

## 2.06 ACCESSORIES

- A. Pressure Relief Valve: Single- or multiple-reseating-type, spring-loaded relief valve.

## 2.07 CONTROLS

- A. Control Panel: Stand-alone, microprocessor based.
- B. Enclosure: Unit-mounted, NEMA 250, Type 1 enclosure, hinged and lockable; factory wired with a single-point power connection and a separate control circuit.
- C. Status Display: Multiple-character liquid-crystal display or light-emitting diodes and keypad. Display the following conditions:
  - 1. Date and time.
  - 2. Operating or alarm status.
  - 3. Operating hours.
  - 4. Outside-air temperature if required for chilled-water reset.
  - 5. Temperature and pressure of operating set points.
  - 6. Entering and leaving temperatures of chilled water.
  - 7. Entering and leaving temperatures of condenser water (for water-cooled water chillers only).
  - 8. Refrigerant pressures in evaporator and condenser.
  - 9. Saturation temperature in evaporator and condenser.
  - 10. Oil temperature and pressure.
  - 11. Percent of maximum motor amperage.
  - 12. Current-limit set point.
  - 13. Number of compressor starts.

D. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water temperature shall be reset based on return-water outside-air space temperature.
3. Current limit and demand limit.
4. Condenser-water temperature.
5. External water chiller emergency stop.

E. Manually Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator pressure; high condenser pressure.
2. Low chilled-water temperature.
3. Low oil differential pressure.
4. High or low oil pressure.
5. High oil temperature.
6. High compressor-discharge temperature.
7. Loss of chilled- or condenser-water flow.
8. Electrical overload.
9. Sensor- or detection-circuit fault.
10. Processor communication loss.
11. Starter fault.

F. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control chilled-water set point and chiller-control displays and alarms.

2.08 MOTORS

A. Refer to Division 15 Section "Motors" for general requirements.

B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

1. Open-drive motors shall have flanged or flexible coupling suitable for direct connection to compressor.

2.09 MAGNETIC ENCLOSED CONTROLLERS

A. Enclosure: Unit mounted, NEMA 250, Type 1, with hinged access door with lock and key or padlock and key.

B. Control Circuit: 120 V; obtained from integral control power transformer with a control power source of enough capacity to operate connected pilot and indicating and control devices.

- C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of water chiller control microprocessor.
- D. Star-Delta Controller: NEMA ICS 2, closed transition.
- E. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
  - 1. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  - 2. Light-emitting-diode indicators showing motor and control status, including the following conditions:
    - a. Controller on.
    - b. Overload trip.
    - c. Loss of phase.
    - d. Starter fault.
- F. Accessories: Devices shall be factory installed in controller enclosure, unless otherwise indicated.
  - 1. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
    - a. Selectable, digital display of the following:
      - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
      - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      - 4) Three-Phase Real Power: Plus or minus 2 percent.
      - 5) Three-Phase Reactive Power: Plus or minus 2 percent.
      - 6) Power Factor: Plus or minus 2 percent.
      - 7) Frequency: Plus or minus 0.5 percent.
      - 8) Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
      - 9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
    - b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.
  - 2. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hard-wired connections.

## 2.10 SOURCE QUALITY CONTROL

- A. Factory test and rate water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle." Stamp with ARI label.
- B. Factory test heat exchangers hydrostatically at 1.50 times the design pressure.

- C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
- D. Factory test and inspect water boxes at 150 percent of working pressure.
- E. Rate sound power level according to ARI 575 procedure.
- F. Rate sound power level according to ARI 370 procedure.
- G. Allow Government access to places where water chillers are being source quality-control tested. Notify Contracting Officer 14 days in advance of testing.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Before water chiller installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
  - 1. Final water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.02 WATER CHILLER INSTALLATION

- A. Install water chillers on concrete base. Concrete base is specified in Division 15 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.
- B. Concrete Bases: Anchor chiller mounting frame to concrete base.
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
  - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 5. Cast-in-place concrete materials and placement requirements are specified in Division 3.
- C. Vibration Isolation: Restrained spring isolators with a minimum deflection of <Insert deflection>. Vibration isolation devices and installation requirements are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."
- D. Maintain manufacturer's recommended clearances for service and maintenance.

- E. Charge water chiller with refrigerant if not factory charged.
- F. Install separate devices furnished by manufacturer.

### 3.03 CONNECTIONS

- A. Chilled- and condenser-water piping installation requirements are specified in Division 15 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to chiller to allow service and maintenance.
- C. Evaporator Connections: Connect inlet to evaporator with controller-bulb well, shutoff valve, thermometer, strainer, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, flow switch, balancing valve, thermometer, pressure gage, and union or flange.
- D. Condenser Connections: Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gage. Connect outlet to condenser with shutoff valve, thermometer, drain line and shutoff valve, strainer, and plugged tee.
- E. Refrigerant Pressure Relief Valve Connections: Extend vent piping to the outside without valves or restrictions.
- F. Ground water chillers according to Division 16 Section "Grounding and Bonding."
- G. Connect wiring according to Division 16 Section "Conductors and Cables."
  - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
- C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
  - 1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
  - 2. Verify that pumps are installed and functional.
  - 3. Verify that thermometers and gages are installed.
  - 4. Operate water chiller for run-in period according to manufacturer's written instructions.
  - 5. Check bearing lubrication and oil levels.
  - 6. Verify that refrigerant pressure relief is vented outside (for water-cooled water chillers).
  - 7. Verify proper motor rotation.

8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
  9. Verify and record performance of chilled- and condenser-water flow and low-temperature interlocks.
  10. Verify and record performance of water chiller protection devices.
  11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Prepare a written startup report that records results of tests and inspections.
- E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.
- 3.05 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain water chillers. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15626



SECTION 15725

MODULAR INDOOR AIR-HANDLING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes constant-volume, modular air-handling units with coils for indoor installations.

1.03 SUBMITTALS

- A. Product Data: For each type of modular indoor air-handling unit indicated. Include the following:
  - 1. Certified fan-performance curves with system operating conditions indicated.
  - 2. Certified fan-sound power ratings.
  - 3. Certified coil-performance ratings with system operating conditions indicated.
  - 4. Motor ratings, electrical characteristics, and motor and fan accessories.
  - 5. Material gages and finishes.
  - 6. Filters with performance characteristics.
  - 7. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
  - 1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- D. Manufacturer Seismic Qualification Certification: Submit certification that modular indoor air-handling units, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." Include the following:
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

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- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Field Quality-Control Test Reports: From manufacturer.

#### 1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of modular indoor air-handling units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
- E. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- F. Comply with NFPA 70.

#### 1.05 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate size and location of structural-steel support members.

#### 1.06 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set for each modular indoor air-handling unit.
  - 2. Fan Belts: One set for each modular indoor air-handling unit fan.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Carrier; Div. of United Technologies Corp.
  2. Dunham-Bush, Inc.
  3. McQuay International.
  4. Trane Company (The); Worldwide Applied Systems Group.
  5. York International Corporation.

### 2.02 MANUFACTURED UNITS

- A. Modular indoor air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, damper, plenums, filters, condensate pans, mixing dampers, control devices, and accessories.

### 2.03 CABINET

- A. Materials: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
1. Outside Casing: Galvanized steel, 0.0635 inch (1.61 mm) thick.
  2. Inside Casing: Galvanized steel, 0.0276 inch (0.7 mm) thick, perforated.
  3. Floor Plate: Galvanized steel, 0.1382 inch (3.5 mm) thick.
- B. Cabinet Insulation: Comply with NFPA 90A or NFPA 90B.
1. Materials: ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers.
  2. Thickness: 2 inches (50 mm).
  3. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.
  4. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C 411.
  5. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C 916.
  6. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
  7. Location and Application: Encased between outside and inside casing.
- C. Access Panels and Doors: Same materials and finishes as cabinet, complete with hinges, latches, handles, and gaskets. Inspection and access panels and doors shall be sized and located to allow periodic maintenance and inspections. Provide access panels and doors in the following locations:

1. Fan Section: Doors.
  2. Access Section: Doors.
  3. Coil Section: Inspection panel.
  4. Damper Section: Doors.
  5. Filter Section: Doors to allow periodic removal and installation of filters.
- D. Condensate Drain Pans: Formed sections of galvanized-steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) and humidifiers when units are operating at maximum catalogued face velocity across cooling coil.
1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
  2. Drain Connections: Both ends of pan.
  3. Pan-Top Surface Coating: Elastomeric compound.
  4. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.

#### 2.04 FAN SECTION

- A. Fan-Section Construction: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan with vibration isolation.
- B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.
1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  2. Performance Class: AMCA 99-2408, Class I.
  3. Horizontal Flanged Split Housing: Bolted construction.
- C. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.
- D. Backward-Inclined Fan Wheels: Steel or Aluminum construction with curved inlet flange, backplate, and backward-inclined blades cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
- E. Forward-Curved Fan Wheels: Black-enamel or galvanized-steel construction with inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
- F. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

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1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
  2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- G. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
1. Ball-Bearing Rating Life: ABMA 9,  $L_{10}$  of 120,000 hours.
- H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor.
1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  2. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  3. Belts: Oil resistant, nonsparking, and nonstatic; matched for multiple belt drives.
  4. Belt Guards: Fabricate to OSHA/SMACNA requirements; 0.1046-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent; prime coated. Provide belt guards for motors mounted on outside of cabinet.
  5. Motor Mount: Adjustable for belt tensioning.
- I. Vibration Control: Install fans on open-spring vibration isolators having a minimum of 1-inch (25-mm) static deflection and side snubbers.
- J. Fan-Section Source Quality Control:
1. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
  2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

## 2.05 MOTORS

- A. General: Refer to Division 15 Section "Motors" for general requirements.
- B. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
- C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range.
- D. Temperature Rating: 50 deg C maximum temperature rise at 40 deg C ambient for continuous duty at full load (Class A Insulation).
- E. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.

- F. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B.
- G. Bearings: The following features are required:
  - 1. Ball or roller bearings with inner and outer shaft seals.
  - 2. Grease lubricated.
  - 3. Designed to resist thrust loading where belt or other drives produce lateral or axial thrust in motor.
- H. Enclosure Type: The following features are required:
  - 1. Open dripproof motors if satisfactorily housed or remotely located during operation.
  - 2. Guarded dripproof motors if exposed to contact with employees or building occupants.
- I. Overload Protection: Built-in, automatically resetting, thermal-overload protection.
- J. Noise Rating: Quiet.
- K. Efficiency: Energy-efficient motors shall have a minimum efficiency as scheduled according to IEEE 112, Test Method B. If efficiency is not specified, motors shall have a higher efficiency than "average standard industry motors" according to IEEE 112, Test Method B.
- L. Nameplate: Indicate ratings, characteristics, construction, special features, and full identification of manufacturer.
- M. Starters, Electrical Devices, and Wiring: Provide combination starter/disconnect switch with thermal overload protection, with integral hand-off-auto selector switch.

## 2.06 COILS

- A. Coil Sections: Common or individual, insulated, galvanized-steel casings for heating and cooling coils. Design and construct to facilitate removal and replacement of coil for maintenance and to ensure full airflow through coils.
- B. Water Coils: Continuous circuit coil fabricated according to ARI 410.
  - 1. Face-and-Bypass Dampers: Extruded-aluminum blades with full-length drive rod.
    - a. Arrangement: Vertical coils.
  - 2. Piping Connections: Threaded, on same end.
  - 3. Tubes: Seamless Copper.
  - 4. Fins: Aluminum.
  - 5. Fin and Tube Joint: Mechanical bond.
  - 6. Headers: Cast iron with drain and air vent tappings.
  - 7. Frames: Galvanized-steel channel frame, 0.052 inch (1.3 mm) 0.064 inch (1.6 mm) 0.079 inch (2.0 mm) 0.0625 inch (1.58 mm).
  - 8. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.

a. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

9. Source Quality Control: Test to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater.

## 2.07 DAMPERS

- A. General: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm (10-m/s) face velocity through damper and 4-inch wg (1000-Pa) pressure differential.
- B. Damper Operators: Electric specified in Division 15 Section "HVAC Instrumentation and Controls."
- C. Low-Leakage, Outside-Air Dampers: Double-skin, airfoil-blade galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade arrangement with steel operating rods rotating in stainless-steel sleeve bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
- D. Face-and-Bypass Dampers: Opposed-blade galvanized-steel dampers with steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame and with operating rods connected with a common linkage. Break-form damper blades, provide gaskets and edge seals, and mechanically fasten to operating rod.
- E. Mixing Boxes: Parallel-blade galvanized-steel dampers mechanically fastened to steel operating rod in reinforced, galvanized-steel cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
- F. Combination Filter and Mixing Box: Parallel-blade galvanized-steel dampers mechanically fastened to steel operating rod in reinforced, galvanized-steel cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat permanent or throwaway filters. Provide hinged access panels or doors to allow removal of filters from both sides of unit.

## 2.08 FILTER SECTION

- A. Filters: Comply with NFPA 90A.
- B. Filter Section: Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side.
- C. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with holding frames.
  - 1. Media: Interlaced glass fibers sprayed with nonflammable adhesive.

2. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
3. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of hydronic and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.02 INSTALLATION

- A. Concrete Bases: Install floor mounting units on 4-inch- (100-mm-) high concrete bases. See Division 15 Section "Basic Mechanical Materials and Methods" for concrete base materials and fabrication requirements.
- B. Install modular indoor air-handling units with the following vibration and seismic-control devices. Vibration and seismic-control devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."
  1. Units with Internally Isolated Fans: Secure units to anchor bolts installed in concrete bases.
  2. Floor-Mounted Units: Support on concrete bases using housed-spring isolators. Secure units to anchor bolts installed in concrete bases.
  3. Suspended Units: Suspend units from structural-steel support frame using threaded steel rods and spring hangers.
- C. Arrange installation of units to provide access space around modular indoor air-handling units for service and maintenance.

#### 3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to modular indoor air-handling units mounted on vibration isolators with flexible connectors.



- D. Connect condensate drain pans using NPS 1-1/4 (DN 32), Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping." Connect to supply and return coil tapings with shutoff or balancing valve and union or flange at each connection.
- F. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.
- G. Electrical: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.
- H. Ground equipment according to Division 16 Section "Grounding and Bonding."
  - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
  - 1. Leak Test: After installation, fill water and steam coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
  - 2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

#### 3.05 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Final Checks before Startup: Perform the following:
  - 1. Verify that shipping, blocking, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Set face-and-bypass dampers to full face flow.
7. Set outside- and return-air mixing dampers to minimum outside-air setting.
8. Comb coil fins for parallel orientation.
9. Install clean filters.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for modular indoor air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for modular indoor air-handling system testing, adjusting, and balancing.

### 3.06 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

### 3.07 CLEANING

- A. Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
- B. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters.

### 3.08 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain modular indoor air-handling units. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15725

SECTION 15731

PACKAGED TERMINAL AIR CONDITIONERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes packaged terminal air conditioners and their accessories and controls, in the following configurations:
  - 1. Through the wall.
  - 2. Heating and cooling unit.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Show installation details, for wall penetrations.
  - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for packaged terminal air conditioners.
- E. Operation and Maintenance Data: For packaged terminal air conditioners to include in emergency, operation, and maintenance manuals.
- F. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Product Options: Information on Drawings and in Specifications establishes requirements for system's aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods including preconstruction testing, field testing, and in-service performance.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

1.05 COORDINATION

- A. Coordinate layout and installation of packaged terminal air conditioners and wall construction with other construction that penetrates walls or is supported by them.

1.06 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged terminal air conditioners that fail in materials or workmanship within specified warranty period.
- B. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Substantial Completion, including components and labor.
- C. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than five years from date of Substantial Completion, including only components and excluding labor.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Carrier Corp.
  - 2. Climate Master, Inc.
  - 3. Friedrich Air Conditioning Co.
  - 4. McQuay International.
  - 5. Trane Company (The); North American Commercial Group.

2.02 MANUFACTURED UNITS

- A. Description: Factory-assembled and tested, self-contained, packaged terminal air conditioner with room cabinet, electric refrigeration system, heating, and temperature controls; fully charged with refrigerant and filled with oil.
  - 1. Power Supply: Cord-connected chassis for 230/208-V units.
- B. Cabinet: 0.052-inch- (1.32-mm-) thick, galvanized steel with removable front panel with concealed latches.

1. Mounting: Wall with wall sleeve.
  2. Finish: Baked enamel.
  3. Discharge Grille and Access Door: Punched-louver discharge grille allowing four-way discharge-air pattern, with hinged door in top of cabinet for access to controls.
  4. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
  5. Subbase: Enameled steel with adjustable leveling feet and adjustable end plates, with factory-installed and -wired, fused disconnect switch and receptacle sized for unit.
  6. Wall Sleeves: Galvanized steel with polyester finish.
  7. Louvers: Extruded aluminum with enamel finish. Color to be selected by Contracting Officer.
- C. Refrigeration System: Direct-expansion indoor coil with capillary restrictor, hermetically sealed scroll compressor with internal spring isolation, external isolation, permanent-split-capacitor motor, and overload protection. Include the following:
1. Outdoor coil and fan.
  2. Accumulator.
  3. Constant-pressure expansion valve.
  4. Reversing valve.
- D. Indoor Fan: Forward curved, centrifugal, with two-speed permanent-split-capacitor motor and positive-pressure ventilation damper with concealed manual operator.
1. Motor: Refer to Division 15 Section "Motors" for general requirements.
    - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - b. Noise Rating: Quiet.
    - c. Electrical devices and connections are specified in Division 16 Sections.
- E. Filters: Washable polyurethane in molded plastic frame.
- F. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.
- G. Condensate Drain: Drain pan to direct condensate to outdoor coil for re-evaporation.
- H. Outdoor Fan: Propeller type driven by indoor fan motor.
1. Motor: Refer to Division 15 Section "Motors" for general requirements.
    - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - b. Noise Rating: Quiet.
    - c. Electrical devices and connections are specified in Division 16 Sections.

2.03 CONTROLS

- A. Control Module: Unit-mounted adjustable thermostat with heat anticipator, off-heat-auto-cool switch, and high-low fan switch.
  - 1. Control Panel Door: Lockable with key.
- B. Low Ambient Lockout Control: Prevents cooling-cycle operation below 40 deg F (5 deg C), outdoor-air temperature.
- C. Fan-Cycle Switch: Allows fan operating mode to be either continuous or cycled on and off by thermostat.
- D. Temperature-Limit Control: Prevents occupant from exceeding preset setback or setup temperature.
- E. Compressor Override: Manual switch prevents compressor operation.
- F. Reverse-Cycle Defrost: Solid-state sensor monitors frost build-up on indoor outdoor coil and reverses unit to melt frost.

2.04 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Factory test to comply with ARI 270, "Sound Rating of Outdoor Unitary Equipment."
- B. Unit Performance Ratings: Factory test to comply with ARI 310/380, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.
- B. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 7 Section "Joint Sealants."
- C. Install wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

3.02 CONNECTIONS

- A. Electrical System Connections: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.
- B. Ground equipment according to Division 16 Section "Grounding and Bonding."

- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 2. After installing packaged terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove malfunctioning units, replace with new units, and retest as specified above.

### 3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. After installation, verify the following:
  - 1. Unit is level on base and is flashed in exterior wall.
  - 2. Unit casing has no visible damage.
  - 3. Compressor, air-cooled condenser coil, and fans have no visible damage.
  - 4. Labels are clearly visible.
  - 5. Controls are connected and operable.
  - 6. Shipping bolts, blocks, and tie-down straps are removed.
  - 7. Filters are installed and clean.
  - 8. Drain pan and drain line are installed correctly.
- C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 16 Sections.
- D. Complete installation and startup checks according to manufacturer's written instructions, including the following:
  - 1. Lubricate bearings on fan.
  - 2. Check fan-wheel rotation for correct direction without vibration and binding.
- E. After startup service and performance test, change filters.

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3.05 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain packaged terminal air conditioners. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15731



SECTION 15543

FUEL-FIRED UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes gas-fired unit heaters.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
  - 1. Design Calculations: Calculate requirements for selecting seismic restraints.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Field Quality-Control Test Reports: From Contractor.
- D. Operation and Maintenance Data: For fuel-fired unit heaters to include in emergency, operation, and maintenance manuals.
- E. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.
- B. Source Limitations: Obtain fuel-fired unit heaters through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, profiles, and dimensional requirements of fuel-fired unit heaters and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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1.05      WARRANTY

- A.    Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchanger of fuel-fired unit heater that fails in materials or workmanship within specified warranty period.
- B.    Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01      MANUFACTURERS

- A.    In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  - 1.    Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.02      GAS-FIRED UNIT HEATERS

- A.    Available Manufacturers:
  - 1.    Modine Mfg. Co.
  - 2.    Reznor/Thomas & Betts.
  - 3.    Sterling Gas-Fired Heating Equipment Div.
  - 4.    Trane Company (The).
- B.    Description: Factory assembled, piped, and wired, and complying with AGA Z83.8, "Gas Unit Heaters."
  - 1.    AGA Approval: Designed and certified by and bearing label of American Gas Association.
  - 2.    Type of Gas: Designed and built to burn natural gas with characteristics same as those of gas available at Project site.
- C.    Venting: Gravity.
- D.    Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
  - 1.    External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
- E.    Heat Exchanger: Aluminized steel.
- F.    Burners: Aluminized steel with stainless-steel inserts.
- G.    Unit Fan: Propeller fan with aluminum blades dynamically balanced and resiliently mounted.
  - 1.    Steel fan-blade guard.

2. Motors: Totally enclosed with internal thermal-overload protection and complying with Division 15 Section "Motors."
- H. Controls: Regulated redundant 24-V ac gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
  1. Gas Control Valve: Single stage.
  2. Ignition: Electronically controlled electric spark with flame sensor.
  3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
  4. Vent Flow Verification: Differential pressure switch to verify open vent.
  5. Control Transformer: 24 V ac.
  6. High Limit: Thermal switch or fuse to stop burner.
  7. Sensors, components, and wiring are specified in Division 15 Section "HVAC Instrumentation and Controls."
  8. Thermostat: Single-stage, 24-V ac, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
- I. Discharge Louvers: Independently adjustable horizontal blades.
- J. Accessories:
  1. Four-point suspension kit.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Examine roughing-in for unit heater piping systems to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.02 INSTALLATION

- A. Install unit heaters level and plumb.
- B. Install and connect gas-fired unit heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.
- C. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
  1. Restrain the unit to resist code-required horizontal acceleration.
- D. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.

1. Anchor the unit to resist code-required horizontal acceleration.

- E. Spring hangers and seismic restraints are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

### 3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Install piping adjacent to machine to allow service and maintenance.

- C. Gas Piping: Comply with applicable requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service. Provide AGA-approved flexible units.

- D. Connect vents according to Division 15 Section "Breechings, Chimneys, and Stacks."

- E. Electrical: Comply with applicable requirements in Division 16 Sections.

1. Install electrical devices furnished with heaters but not specified to be factory mounted.

- F. Ground equipment according to Division 16 Section "Grounding and Bonding."

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections.

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:
  - a. Test procedures used.
  - b. Test results that comply with requirements.
  - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

### 3.05 ADJUSTING

- A. Adjust initial temperature and humidity set points.

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- B. Adjust burner and other unit components for optimum heating performance and efficiency.
- 3.06 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain fuel-fired unit heaters. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 15543



SECTION 15550

BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

- 1. Listed double-wall vents.
- 2. Listed dishwasher ducts.

1.03 SUBMITTALS

- A. Product Data: For the following:

- 1. Type B vents.

- B. Shop Drawings: For vents. Include plans, elevations, sections, details, and attachments to other work.

- 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
- 2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

- C. Welding certificates.

- D. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain listed system components through one source from a single manufacturer.
- B. Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.
- C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.05 COORDINATION

- A. Coordinate installation of roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.06 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.
- B. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.02 LISTED TYPE B VENTS

- A. Available Manufacturers:
  - 1. Heat-Fab Inc.
  - 2. Metal-Fab, Inc.
  - 3. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
- B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B, with neutral or negative flue pressure complying with NFPA 211 and suitable for certified gas-fired appliances.
- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
- D. Inner Shell: ASTM A 666, Type 430 stainless steel.
- E. Outer Jacket: Aluminized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
  - 1. Termination: Stack cap designed to exclude 90 percent of rainfall.



2.03 GUYING AND BRACING MATERIALS

- A. Cable: Three galvanized, stranded wires of the following thickness:
  - 1. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF LISTED VENTS

- A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

3.03 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
- B. Provide temporary closures at ends of vents that are not completed or connected to equipment.

END OF SECTION 15550



SECTION 15562

INDIRECT-FIRED H&V UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes indirect-fired H&V units with the following accessories:

- 1. Gas furnace.

- B. Related Sections include the following:

- 1. Division 15 Section "Breechings, Chimneys, and Stacks" for vent piping.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and methods of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:

- 1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
  - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
  - 3. Wiring Diagrams: Power, signal, and control wiring.

- C. Startup service reports.

- D. Operation and Maintenance Data: For indirect-fired H&V units to include in emergency, operation, and maintenance manuals.

- E. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of indirect-fired H&V units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- C. Comply with NFPA 70.

#### 1.05 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate size, location and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

#### 1.06 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below of indirect-fired H&V units that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

#### 1.07 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set for each unit.
  - 2. Fan Belts: One set for each unit.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. BessamAire, Inc.
  - 2. Hastings Industries; Division of Eric, Inc.
  - 3. Jackson & Church; Div. of Donlee Technologies Inc.
  - 4. Reznor-Thomas & Betts Corporation; Mechanical Products Division.
  - 5. Sterling Gas; Mestek, Inc.
  - 6. Trane Company (The); Unitary Products Group.

2.02 PACKAGED UNITS

- A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and indirect-fired gas furnace to be installed inside the building.

2.03 CABINET

- A. Cabinet: Double-wall galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs.
- B. Access Panels: Lift-out for furnace and fan motor assemblies on both sides of unit.
- C. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on complete unit.
  - 1. Thickness: 1 inch (25 mm).
  - 2. Insulation Adhesive: Comply with ASTM C 916, Type I.
  - 3. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
- D. Finish: Heat-resistant, baked enamel.

2.04 SUPPLY-AIR FAN

- A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings.
- B. Motor: Open dripproof, single-speed motor.
- C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
- D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with elastomeric isolators.

2.05 AIR FILTERS

- A. Comply with NFPA 90A.
- B. Cleanable Filters: 1-inch- (25-mm-)thick, cleanable metal mesh.

2.06 DAMPERS

- A. Outdoor-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 2-inch wg (448 Pa).

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- B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

## 2.07 INDIRECT-FIRED GAS FURNACE

- A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and NFPA 54, "National Fuel Gas Code."

- 1. AGA Approval: Designed and certified by and bearing label of AGA.
- 2. Burners: Aluminized steel with stainless-steel inserts.
  - a. Gas Control Valve: Modulating.
  - b. Fuel: Natural gas.
  - c. Minimum Thermal Efficiency: 80 percent.
  - d. Ignition: Electronically controlled electric spark with flame sensor.

- B. Venting: Gravity vented.

- C. Inside Unit External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.

- 1. External Casing and Cabinet Finish: Baked enamel over corrosion-resistant-treated surface in color to match fan section.

- D. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.

- E. Heat Exchanger: Aluminized steel.

- F. Heat-Exchanger Drain Pan: Stainless steel.

- G. Safety Controls:

- 1. Vent Flow Verification: Differential pressure switch to verify open vent or flame rollout switch.
- 2. Control Transformer: 24-V ac.
- 3. High Limit: Thermal switch or fuse to stop burner.
- 4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
- 5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
- 6. Gas Manifold: Safety switches and controls to comply with ANSI standards.
- 7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
- 8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
- 9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.08 CONTROLS

- A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
- B. Control Panel: Surface-mounted, remote panel, with engraved plastic cover, and the following lights and switches:
  - 1. On-off-auto fan switch.
  - 2. Supply-fan operation indicating light.
  - 3. Heating operation indicating light.
  - 4. Thermostat.
  - 5. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
  - 6. Safety-lockout indicating light.
- C. Refer to Division 15 Section "HVAC Instrumentation and Controls" for control equipment and sequence of operation.
- D. Control Devices:
  - 1. Remote Thermostat: Adjustable room thermostat with temperature readout.
- E. Fan Control: DDC starts and stops indirect-fired H&V unit and exhaust fan.
  - 1. Fan-Discharge Thermostat: Stops fan on burner failure when outdoor-air temperature is less than 40 deg F (4 deg C).
  - 2. Smoke detectors, located in supply air, shall stop fans when the presence of smoke is detected.
- F. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
- G. Temperature Control: Operates gas valve to maintain supply-air temperature.
  - 1. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment.
  - 2. Furnace Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual furnace units.
- H. DDC: Stand-alone control module for link between unit controls and DDC system. Control module shall be compatible with temperature-control system specified in Division 15 Section "HVAC Instrumentation and Controls."
  - 1. Provide start and stop interface relay, and relay to notify DDC system alarm condition.
  - 2. Provide hardware interface or additional sensors as follows:
    - a. Room temperature.
    - b. Discharge-air temperature.
    - c. Furnace operating.

**2.09 MOTORS**

- A. General requirements for motors are specified in Division 15 Section "Motors."
- B. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

**2.10 CAPACITIES AND CHARACTERISTICS**

- A. Refer to schedule on drawings for capacities and characteristics:

**PART 3 - EXECUTION**

**3.01 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation of indirect-fired H&V units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.02 INSTALLATION**

- A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- B. Install floor-mounted units on restrained, spring isolators with minimum 1-inch (25-mm) static deflection; refer to Division 15 Section "Mechanical Vibration and Seismic Controls."
- C. Install controls and equipment shipped by manufacturer for field installation with indirect-fired H&V units.

**3.03 CONNECTIONS**

- A. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.
  - 1. Gas Piping: Comply with requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.
- B. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to indirect-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Duct Accessories."
- C. Ground equipment according to Division 16 Section "Grounding and Bonding."



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- D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to furnace combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.
11. Start unit according to manufacturer's written instructions.
12. Complete startup sheets and attach copy with Contractor's startup report.
13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for run-in period recommended by manufacturer.
15. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

a. Gas Burner:

- 1) Measure gas pressure at manifold.
  - 2) Measure combustion-air temperature at inlet to combustion chamber.
  - 3) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
16. Calibrate thermostats.
  17. Adjust and inspect high-temperature limits.
  18. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
  19. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
  20. Measure and record airflow. Plot fan volumes on fan curve.
  21. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
    - a. High-limit heat.
    - b. Alarms.
  22. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

- C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.
- D. Prepare written report of the results of startup services.

**3.05 ADJUSTING**

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

**3.06 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain indirect-fired H&V units. Refer to Division 1 Section "Closeout Procedures."

**END OF SECTION 15562**

SECTION 15738

SPLIT-SYSTEM AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.
- B. Related Sections include the following:
  - 1. Division 15 Section "Mechanical Vibration Isolation and Seismic Restraints" for isolation pads, spring isolators, and seismic restraints.
  - 2. Division 15 Section "HVAC Instrumentation and Controls" for control devices not packaged with units.
  - 3. Division 15 Section "Sequence of Operation" for control sequences affecting operation of units.

1.03 DEFINITIONS

- A. Evaporator-Fan Unit: The part of the split-system air-conditioning unit that contains a coil for cooling (heat rejection for heating operation in heat pump units) and a fan to circulate air to conditioned space.
- B. Compressor-Condenser Unit: The part of the split-system air-conditioning unit that contains a refrigerant compressor and a coil for condensing refrigerant (evaporator for heating operation in heat pump units).

1.04 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.
- C. Samples for Initial Selection: Manufacturer's color charts consisting of units of sections of units showing the full range of colors available for units with factory-applied color finishes.

D. Maintenance Data: For split-system air-conditioning units to include in maintenance manuals specified in Division 1.

E. Warranties: Special warranties specified in this Section.

#### 1.05 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

#### 1.06 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Government of other rights Government may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

C. Warranty Period: Five years from date of substantial completion.

#### 1.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set of filters for each unit.
2. Fan Belts: One set of belts for each unit.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Carrier Air Conditioning; Div. of Carrier Corp.
2. Lennox Industries Inc.
3. Trane Co. (The); Unitary Products Group.
4. York International Corp.

2.02 WALL- OR CEILING-MOUNTED, EVAPORATOR-FAN COMPONENTS

- A. Cabinet: Enameled steel with removable panels on front and ends, and discharge drain pans with drain connection.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
- C. Fan and Motor: Centrifugal fan, directly driven by multispeed, electric motor with integral overload protection; resiliently mounted.
- D. Filters: Permanent, cleanable.

2.03 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

- A. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
  - 1. Compressor Type: Reciprocating or Scroll.
  - 2. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
- D. Fan: Aluminum-propeller type, directly connected to motor.
- E. Motor: Permanently lubricated, with integral thermal-overload protection.
- F. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
- G. Mounting Base: Polyethylene.

2.04 ACCESSORIES

- A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
- B. Automatic-reset timer to prevent rapid cycling of compressor.
- C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 3, "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
- D. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
- E. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch (25 mm). Refer to Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
- F. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

#### 3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Unless otherwise indicated, connect piping with unions and shutoff valves to allow units to be disconnected without draining piping. Refer to piping system Sections for specific valve and specialty arrangements.
- D. Ground equipment.
  - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.03 FIELD QUALITY CONTROL

- A. Installation Inspection: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to prepare a written report of inspection.

- B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.
- D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

#### 3.04 COMMISSIONING

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that units are installed and connected according to the Contract Documents.
- C. Lubricate bearings, adjust belt tension, and change filters.
- D. Perform startup checks according to manufacturer's written instructions and do the following:
  - 1. Fill out manufacturer's checklists.
  - 2. Check for unobstructed airflow over coils.
  - 3. Check operation of condenser capacity-control device.
  - 4. Verify that vibration isolation devices and flexible connectors dampen vibration transmission to structure.

#### 3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain units.
  - 1. Train Government's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining units.
  - 2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
  - 3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  - 4. Schedule training with Government, through Contracting Officer, with at least seven days' advance notice.

END OF SECTION 15738





SECTION 15761

AIR COILS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
  - 1. Hot-water coils
- B. Related Sections include the following:
  - 1. Division 15 Section "HVAC Instrumentation and Controls" for coil temperature-control valve requirements.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities of selected models; pressure drop; shipping, installed, and operating weights; installation instructions; and startup instructions for each type of product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
- C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating coil location and ceiling-mounted access panels.
- D. Maintenance Data: For air coils to include in maintenance manuals specified in Division 1.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with ARI 410, "Standard for Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.

1. Certify coils to ARI 410, "Standard for Forced-Circulation Air-Cooling and Air-Heating Coils."

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Water Coils:
  - a. Coil Company Inc.
  - b. Dunham-Bush, Inc.
  - c. Heatcraft Inc.; Heat Transfer Division.
  - d. Trane Co. (The).
  - e. USA Coil and Air.

### 2.02 HOT-WATER COILS

- A. Description: Continuous circuit coil fabricated to ARI 410.
- B. Piping Connections: Threaded, on same end.
- C. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).
  1. Tube Diameter: 0.625 inch (15.9 mm) 0.50 inch (12.7 mm) 0.375 inch (9.5 mm) 0.75 inch (19.0 mm) 1.0 inch (25.4 mm).
- D. Fins: Aluminum.
- E. Fin and Tube Joint: Mechanical bond.
- F. Headers: Cast iron with drain and air vent tappings.
- G. Frames: Galvanized-steel channel frame, 0.052 inch (1.3 mm).
- H. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
  1. Working Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
- I. Source Quality Control: Test to 300 psig (2070 kPa), and to 200 psig (1380 kPa) underwater.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Examine ducts, plenums, and units to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.02 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

#### 3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Unless otherwise indicated, connect piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Refer to piping system Sections for specific valve and specialty arrangements.
- D. Ground equipment.
  - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.04 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Straighten bent fins on each air coil.

#### 3.05 CLEANING

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

- B. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

END OF SECTION 15761

SECTION 15762

ELECTRIC RADIATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
  - 1. Finned-tube radiators.
- B. Related Sections include the following:
  - 1. Division 15 Section "Cabinet Unit Heaters" for terminal heating units with electric-resistance heating elements.
  - 2. Division 15 Section "Propeller Unit Heaters" for terminal heating units with electric-resistance heating elements.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For electric radiators to include in maintenance manuals.
- E. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric radiators that fail in materials or workmanship within specified warranty period.

1. Warranty Period Radiation Heating Element): 10 years from date of Substantial Completion.
2. Warranty Period (Electronic Thermostat): Two years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

### 2.02 FINNED-TUBE RADIATORS

- A. Available Manufacturers:

1. Berko Electric Heating.
2. Chromalox; Division of Emerson Electric Company.
3. Marley Electric Heating; a United Dominion Company.
4. Qmark Electric Heating.

- B. Heating Elements: Nickel-chromium heating wire element enclosed in metallic sheath mechanically expanded into fins, with high-temperature cutout. Element supports eliminate thermal expansion noise.

- C. Enclosures: Galvanized steel with easily jointed components for wall-to-wall installation, rigidly supported on wall- or floor-mounting brackets.

1. Enclosures 18 Inches (450 mm) and Less in Height: 0.0478-inch- (1.2-mm-) thick steel.
2. Support Brackets: Locate at maximum 36-inch (900-mm) spacing.
3. Finish: Factory-applied baked enamel in color selected by Contracting Officer from manufacturer's standard colors.
4. Enclosure Style: Flat top with front grille, with front inlet grille.

- D. Unit Controls: Integral line-voltage thermostat with range of 40 to 100 deg F (5 to 40 deg C).

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Examine roughing-in for electric radiators to verify actual locations of electrical connections before equipment installation.

- B. Examine walls for suitable conditions where electric radiators will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.02 INSTALLATION

- A. Install finned-tube radiators level and plumb and according to the following, unless otherwise indicated:
  - 1. Center units' heating element and enclosure under windows.
  - 2. Install manufacturer's access fitting in cabinets for access to electrical connections, controls, and other fittings.
  - 3. Terminate enclosures with manufacturer's end caps.

### 3.03 CONNECTIONS

- A. Ground equipment according to Division 16 Section "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section "Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.04 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and prepare test reports:
  - 1. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 15762





SECTION 15763

FAN-COIL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes fan-coil units and accessories.

1.03 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each fan-coil unit type and configuration:
  - 1. Plans, elevations, sections, and details.
  - 2. Details of anchorages and attachments to structure and to supported equipment.
  - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
  - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
  - 1. Ceiling suspension assembly members.
  - 2. Method of attaching hangers to building structure.
- D. Field Test Reports: Written reports of tests specified in Part 3 of this Section.
- E. Maintenance Data: For fan-coil units to include in maintenance manuals specified in Division 1. Include the following:
  - 1. Maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 COORDINATION

- A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.06 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fan-Coil Unit Filters: Furnish spare filter for each filter installed.
  - 2. Fan Belts: Furnish one spare fan belt for each unit installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Carrier Corp.
  - 2. Dunham-Bush, Inc.
  - 3. Lennox Industries Inc.
  - 4. McQuay International.
  - 5. Trane Company (The); North American Commercial Group.
  - 6. U S A Coil & Air Inc.
  - 7. York International Corp.

2.02 CONFIGURATION

- A. Horizontal Units: An assembly including cabinet, filter, chassis, coil, drain pan, fan, and motor in blow-through configuration with hydronic cooling coil.

2.03 MATERIALS

- A. Chassis: Galvanized steel, with flanged edges.
- B. Coil Section Insulation: 1-inch (25-mm) duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
  - 1. Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.
- C. Drain Pans: Galvanized steel, with connection for drain. Drain pan shall have a removable plastic liner and be insulated with polystyrene or polyurethane insulation. Drain pan and liner shall be formed to slope from all directions to drain connection.

D. Cabinet: Galvanized steel, with removable panels.

1. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain.

E. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer with manufacturer's standard paint, in color selected by Contracting Officer, applied to factory-assembled and -tested fan-coil unit before shipping.

#### 2.04 WATER COILS

- A. Chilled Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and with manual air vent. Coils shall be rated for a minimum working pressure of 300 psig (2068 kPa) and a maximum entering water temperature of 275 deg F (135 deg C).

#### 2.05 FAN

- A. Centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel or thermoplastic material; directly connected to or V-belt driven from motor.

#### 2.06 FAN MOTORS

- A. Motors for Direct-Drive Units: Multispeed motor with integral thermal-overload protection and resilient mounts.
- B. Motors for Belt-Drive Units: Open dripproof with hinged mount and adjustable motor pulley.
- C. Wiring Terminations: Match conductor materials and sizes of connecting power circuit. Connect motor to chassis wiring with plug connection.

#### 2.07 ACCESSORIES

- A. Steel subbase.
- B. Plastic motor-oiler tubes extending to beneath top of discharge grille.
- C. Filters: 1-inch- (25-mm-) thick, throwaway filters in fiberboard frames.
- D. Dampers: Steel damper blades with polyurethane stop across entire blade length and having factory-mounted electric operators for 25 percent open cycle.

#### 2.08 CONTROL SYSTEMS

- A. Refer to other Division 15 sections.

#### 2.09 SOURCE QUALITY CONTROL

- A. Test and rate units according to ARI 440.

- B. Test unit coils according to ASHRAE 33.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.02 INSTALLATION

- A. Install fan-coil units level and plumb.
- B. Install fan-coil units to comply with NFPA 90A.
- C. Suspend fan-coil units from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

#### 3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Ground equipment.
  - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.04 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
  - 1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Test and adjust controls and safeties.
- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.05 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean fan-coil units internally according to manufacturer's written instructions.
- C. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain fan-coil units.
  - 1. Train Government's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
  - 2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
  - 3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  - 4. Schedule training with Government, through Contracting Officer, with at least seven days' advance notice.

END OF SECTION 15763



SECTION 15766

CABINET UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes cabinet unit heaters.

1.03 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each unit type and configuration:
  - 1. Plans, elevations, sections, and details.
  - 2. Details of anchorages and attachments to structure and to supported equipment.
  - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
  - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
  - 1. Ceiling suspension assembly members.
  - 2. Method of attaching hangers to building structure.
  - 3. Size and location of initial access modules for acoustical tile.
  - 4. Size and location of access panels in hard ceilings to provide access to concealed units.
  - 5. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- D. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.
- E. Field Test Reports: Written reports of tests specified in Part 3 of this Section.
- F. Maintenance Data: For cabinet unit heaters to include in maintenance manuals specified in Division 1. Include the following:
  - 1. Maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 COORDINATION

- A. Coordinate layout and installation of cabinet unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.06 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Cabinet Unit Heater Filters: Furnish one spare filter for each filter installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- 1. Dunham-Bush, Inc.
  - 2. McQuay International.
  - 3. Trane Company (The); North American Commercial Group.
  - 4. U S A Coil & Air Inc.

2.02 CABINET UNIT HEATERS

- A. Description: An assembly including filter, chassis, coil, fan, and motor in blow-through configuration with heating coil.
- B. Cabinet: For one or more of the following configurations:
  - 1. Surface, wall mounting.
    - a. Air Inlet: Open bottom Front grille or open bottom as indicated.
    - b. Air Outlet: Front grille.
  - 2. Recessed, wall-mounting front grilles for air inlet and outlet.
  - 3. Recessed, ceiling-mounting front grilles for air inlet and outlet.
- C. Airflow: Up flow.



2.03 MATERIALS

- A. Chassis: Galvanized steel, with flanged edges and unit-leveling bolts.
- B. Coil Section Insulation: 1-inch (25-mm) duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
  - 1. Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.
- C. Cabinet: Galvanized steel, with removable panels fastened with tamperproof fasteners and key-operated access door.
- D. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer with manufacturer's standard paint, in color selected by Contracting Officer, applied to factory-assembled and -tested cabinet unit heater before shipping.

2.04 COILS

- A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and with manual air vent. Coils shall be rated for a minimum working pressure of 300 psig (2068 kPa) and a maximum entering water temperature of 275 deg F (135 deg C), with manual air vent.

2.05 FAN

- A. Centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel or thermoplastic material; directly connected to motor.

2.06 FAN MOTORS

- A. Multispeed motor with integral thermal-overload protection and resilient mounts. Connect motor to chassis wiring with plug connection.

2.07 ACCESSORIES

- A. Steel subbase, height as indicated.
- B. Plastic motor-oiler tubes extending to beneath top discharge grille.
- C. Steel recessing flanges for recessing cabinet unit heaters into ceiling.
- D. Filters: 1/2-inch- (13-mm-) thick, glass-fiber media in aluminum frame.

2.08 CONTROLS

- A. Control Devices: Unit-mounted fan-speed switch and thermostat.

2.09 SOURCE QUALITY CONTROL

- A. Test cabinet unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before cabinet unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install cabinet unit heaters level and plumb.
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Suspend cabinet unit heaters from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Ground equipment.
- E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
  - 1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Test and adjust controls and safeties.

- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.05 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean cabinet unit heaters internally according to manufacturer's written instructions.
- C. Install new filters in each cabinet unit heater within two weeks after Substantial Completion.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.
  - 1. Train Government's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
  - 2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
  - 3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  - 4. Schedule training with Government, through Contracting Officer, with at least seven days' advance notice.

END OF SECTION 15766



SECTION 15767

PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes propeller unit heaters.

1.03 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each unit type and configuration:
  - 1. Plans, elevations, sections, and details.
  - 2. Details of anchorages and attachments to structure and to supported equipment.
  - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
  - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
- C. Field Test Reports: Written reports of tests specified in Part 3 of this Section.
- D. Maintenance Data: For propeller unit heaters to include in maintenance manuals specified in Division 1. Include the following:
  - 1. Maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 COORDINATION

- A. Coordinate layout and installation of propeller unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

**PART 2 - PRODUCTS**

**2.01 MANUFACTURERS**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Dunham-Bush, Inc.
  - 2. McQuay International.
  - 3. Trane Company (The); North American Commercial Group.
  - 4. U S A Coil & Air Inc.

**2.02 UNIT HEATERS**

- A. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with horizontal, adjustable louvers in blow-through configuration.

**2.03 MATERIALS**

- A. Casing: Galvanized steel, with removable panels.
- B. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.

**2.04 COILS**

- A. Hot-Water Coil: Copper tube, 0.031-inch (0.78-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 375 psig (2690 kPa) underwater.

**2.05 FAN**

- A. Propeller with aluminum blades directly connected to motor.

**2.06 FAN MOTORS**

- A. Motors, 1/2 hp and Smaller: Multispeed motor with integral thermal-overload protection.
- B. Motors, 3/4 hp and Larger: Totally enclosed with permanently lubricated ball bearings.

**2.07 ACCESSORIES**

- A. Horizontal Configuration: Louver fin diffuser.

**2.08 CONTROLS**

- A. Control Devices: Unit-mounted fan-speed switch and wall-mounting thermostat.

2.09 SOURCE QUALITY CONTROL

- A. Test propeller unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before propeller unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install propeller unit heaters level and plumb.
- B. Install propeller unit heaters to comply with NFPA 90A.
- C. Suspend propeller unit heaters from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
- D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange on each connection.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Ground equipment.
- E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.04 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:

1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.

- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.05 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean propeller unit heaters internally according to manufacturer's written instructions.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain propeller unit heaters.
1. Train Government's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
  2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
  3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  4. Schedule training with Government, through Contracting Officer, with at least seven days' advance notice.

END OF SECTION 15767



SECTION 15815

METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2500 Pa). Metal ducts include the following:
  - 1. Rectangular ducts and fittings.
  - 2. Single-wall, round spiral-seam ducts and formed fittings.
  - 3. Duct liner.
- B. Related Sections include the following:
  - 1. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.03 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Contracting Officer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.04 SUBMITTALS

- A. Shop Drawings: Drawn to 1/4 inch equals 1 foot (1:50) scale. Show fabrication and installation details for metal ducts.
  - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - 2. Duct layout indicating sizes and pressure classes.
  - 3. Elevations of top and bottom of ducts.
  - 4. Dimensions of main duct runs from building grid lines.
  - 5. Fittings.
  - 6. Reinforcement and spacing.
  - 7. Seam and joint construction.
  - 8. Penetrations through fire-rated and other partitions.

9. Equipment installation based on equipment being used on Project.
  10. Duct accessories, including access doors and panels.
  11. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Ceiling suspension assembly members.
  2. Other systems installed in same space as ducts.
  3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
  4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- C. Welding certificates.
- D. Field quality-control test reports.

#### 1.05 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports; AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members; and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. NFPA Compliance:
1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
  2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

## 2.02 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 (Z180) G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- D. Stainless Steel: ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed ducts and No. 4 finish for surfaces for exposed ducts.
- E. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

## 2.03 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
  - 1. Available Manufacturers:
    - a. CertainTeed Corp.; Insulation Group.
    - b. Johns Manville International, Inc.
    - c. Knauf Fiber Glass GmbH.
    - d. Owens Corning.
  - 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
    - a. Thickness: 1 inch (25 mm).
    - b. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.
    - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
    - d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
    - e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner

when applied as recommended by manufacturer and without causing leakage in duct.

- 1) Tensile Strength: Indefinitely sustain a 50-lb- (23-kg-) tensile, dead-load test perpendicular to duct wall.
- 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch (3 mm) into airstream.
- 3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

B. Flexible Elastomeric Duct Liner: Comply with NFPA 90A or NFPA 90B.

1. Available Manufacturers:

- a. Armstrong World Industries, Inc.
- b. Imcoa.

2. Materials: Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.

- a. Thickness: 1 inch (25 mm).
- b. Thermal Conductivity (k-Value): 0.24 at 75 deg F (0.034 at 24 deg C) mean temperature.
- c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
- d. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.04 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- B. Joint and Seam Tape: 2 inches (50 mm) wide; glass-fiber-reinforced fabric.
- C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- D. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
- E. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- F. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.05 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
  - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
  - 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
  - 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
  - 3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
  - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
  - 2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
  - 3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.06 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
  - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
  - 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of nonbraced panel area unless ducts are lined.

## 2.07 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).
- G. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
  - 1. Fan discharges.
  - 2. Intervals of lined duct preceding unlined duct.
  - 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.
- I. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
  - 1. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
- J. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

## 2.08 ROUND DUCT AND FITTING FABRICATION

- A. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
  - 1. Available Manufacturers:

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- a. McGill AirFlow Corporation.
  - b. SEMCO Incorporated.
- B. Duct Joints:
  - 1. Ducts up to 20 Inches (500 mm) in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
  - 2. Ducts 21 to 72 Inches (535 to 1830 mm) in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
  - 3. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
    - a. Available Manufacturers:
      - 1) Lindab Inc.
- C. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- D. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- E. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
  - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
  - 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg (minus 500 to plus 500 Pa):
    - a. Ducts 3 to 36 Inches (75 to 915 mm) in Diameter: 0.034 inch (0.85 mm).
    - b. Ducts 37 to 50 Inches (940 to 1270 mm) in Diameter: 0.040 inch (1.0 mm).
  - 3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg (500 to 2500 Pa):
    - a. Ducts 3 to 26 Inches (75 to 660 mm) in Diameter: 0.034 inch (0.85 mm).
  - 4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
  - 5. Round Elbows 8 Inches (200 mm) and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only.

- Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
6. Round Elbows 9 through 14 Inches (225 through 355 mm) in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
  7. Round Elbows Larger Than 14 Inches (355 mm) in Diameter: Fabricate gored elbows unless space restrictions require mitered elbows.
  8. Die-Formed Elbows for Sizes through 8 Inches (200 mm) in Diameter and All Pressures 0.040 inch (1.0 mm) thick with 2-piece welded construction.
  9. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
  10. Pleated Elbows for Sizes through 14 Inches (355 mm) in Diameter and Pressures through 10-Inch wg (2500 Pa): 0.022 inch (0.55 mm).

### PART 3 - EXECUTION

#### 3.01 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply Ducts: 2-inch wg (500 Pa).
  2. Supply Ducts (before Air Terminal Units): 2-inch wg (500 Pa).
  3. Supply Ducts (after Air Terminal Units): 1-inch wg (250 Pa).
  4. Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa).
  5. Return Ducts (Negative Pressure): 1-inch wg (250 Pa).
  6. Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa).
- B. All ducts shall be galvanized steel except as follows:
1. Range Hood Exhaust Ducts: Comply with NFPA 96.
    - a. Concealed: Carbon-steel sheet.
    - b. Exposed: Type 304, stainless steel with finish to match kitchen equipment and range hood.
    - c. Weld and flange seams and joints.
  2. Dishwasher Hood Exhaust Ducts:
    - a. Type 304, stainless steel with finish to match kitchen equipment and range hood. Weld and flange seams and joints.
    - b. Aluminum, with seams and laps arranged on top of duct.
  3. Acid-Resistant (Fume-Handling) Ducts: Type 304, stainless-steel sheet with No. 4 finish.



**3.02 DUCT INSTALLATION**

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round ducts in lengths not less than 12 feet (3.7 m) unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches (300 mm), with a minimum of 3 screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches (38 mm).
- N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."
- O. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

3.03 RANGE HOOD EXHAUST DUCTS, SPECIAL INSTALLATION REQUIREMENTS

- A. Install ducts to allow for thermal expansion through 2000 deg F (1110 deg C) temperature range.
- B. Install ducts without dips or traps that may collect residues unless traps have continuous or automatic residue removal.
- C. Install access openings at each change in direction and at intervals defined by NFPA 96; locate on sides of duct a minimum of 1-1/2 inches (38 mm) from bottom; and fit with grease-tight covers of same material as duct.
- D. Do not penetrate fire-rated assemblies except as permitted by applicable building codes.

3.04 SEAM AND JOINT SEALING

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.
  - 1. For pressure classes lower than 2-inch wg (500 Pa), seal transverse joints.
- B. Seal ducts before external insulation is applied.

3.05 HANGING AND SUPPORTING

- A. Support horizontal ducts within 24 inches (600 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
- B. Support vertical ducts at maximum intervals of 16 feet (5 m) and at each floor.
- C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- D. Install concrete inserts before placing concrete.
- E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

3.06 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.07 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
  - 1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - 2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
  - 3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (500 Pa) (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg (500 to 2500 Pa).
  - 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.08 CLEANING NEW SYSTEMS

- A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
- B. Use service openings, as required, for physical and mechanical entry and for inspection.
  - 1. Create other openings to comply with duct standards.
  - 2. Disconnect flexible ducts as needed for cleaning and inspection.
  - 3. Remove and reinstall ceiling sections to gain access during the cleaning process.
- C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.
- D. Clean the following metal duct systems by removing surface contaminants and deposits:
  - 1. Air outlets and inlets (registers, grilles, and diffusers).
  - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
  - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, filters and filter sections, and condensate collectors and drains.
  - 4. Coils and related components.
  - 5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
  - 6. Supply-air ducts, dampers, actuators, and turning vanes.

**E. Mechanical Cleaning Methodology:**

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

**F. Cleanliness Verification:**

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

END OF SECTION 15815

SECTION 15820

DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

1. Volume dampers.
2. Motorized control dampers.
3. Fire dampers.
4. Turning vanes.
5. Duct-mounting access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Duct accessory hardware.

- B. Related Sections include the following:

1. Division 13 Section "Fire Alarm" for duct-mounting fire and smoke detectors.
2. Division 15 Section "HVAC Instrumentation and Controls" for electric damper actuators.
3. Division 16 Sections for duct-mounted smoke detectors.

1.03 SUBMITTALS

- A. Product Data: For the following:

1. Volume dampers.
2. Motorized control dampers.
3. Fire dampers.
4. Ceiling fire dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Turning vanes.
8. Duct-mounting access doors.
9. Flexible connectors.
10. Flexible ducts.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Special fittings.
2. Manual-volume damper installations.
3. Motorized-control damper installations.
4. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
5. Wiring Diagrams: Power, signal, and control wiring.

- C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

#### 1.04 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

#### 1.05 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

### PART 2 - PRODUCTS

#### 2.01 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- E. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

#### 2.02 VOLUME DAMPERS

- A. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed

position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
  1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
  2. Roll-Formed Steel Blades: 0.064-inch- (1.62-mm-) thick, galvanized sheet steel.
  3. Blade Axles: Galvanized steel.
  4. Bearings: Molded synthetic.
  5. Tie Bars and Brackets: Galvanized steel.
- C. Jackshaft: 1-inch- (25-mm-) diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
  1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
- D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

## 2.03 MOTORIZED CONTROL DAMPERS

- A. General Description: AMCA-rated, opposed-blade design; minimum of 0.1084-inch- (2.8-mm) thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- (1.61-mm-) thick, galvanized-steel damper blades with maximum blade width of 8 inches (203 mm).
  1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
  2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
  3. Provide closed-cell neoprene edging.

## 2.04 FIRE DAMPERS

- A. Fire dampers shall be labeled according to UL 555.
- B. Fire Rating: 3 hours.

- C. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- D. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
  - 1. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick as indicated and of length to suit application.
  - 2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
- E. Mounting Orientation: Vertical or horizontal as indicated.
- F. Blades: Roll-formed, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- G. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- H. Fusible Links: Replaceable, 165 deg F (74 deg C) rated.

## 2.05 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- (38-mm-) wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch (19 mm) o.c.; support with bars perpendicular to blades set 2 inches (50 mm) o.c.; and set into vane runners suitable for duct mounting.

## 2.06 DUCT-MOUNTING ACCESS DOORS

- A. General Description: Fabricate doors airtight and suitable for duct pressure class.
- B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
  - 1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
  - 2. Provide number of hinges and locks as follows:
    - a. Less Than 12 Inches (300 mm) Square: Secure with two sash locks.
    - b. Up to 18 Inches (450 mm) Square: Two hinges and two sash locks.
    - c. Up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
- C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch (25-mm) thickness. Include cam latches.



1. Frame: Galvanized sheet steel, with spin-in notched frame.
- D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
- E. Insulation: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

#### 2.07 FLEXIBLE CONNECTORS

- A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- B. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Select metal compatible with ducts.
- C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
  2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
  3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

#### 2.08 FLEXIBLE DUCTS

- A. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene aluminized vapor barrier film.
  1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
  2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
  3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
- B. Insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
  1. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
  2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
  3. Temperature Range: Minus 20 to plus 175 deg F (Minus 28 to plus 79 deg C).
- C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches (75 to 450 mm) to suit duct size.

#### 2.09 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

### PART 3 - EXECUTION

#### 3.01 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- B. Provide duct accessories of materials suited to duct materials.
- C. Install motorized dampers on exhaust fans or exhaust ducts where indicated.
- D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
- E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.
- F. Provide test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire dampers, with fusible links, according to manufacturer's UL-approved written instructions.
- H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
  - 1. On both sides of duct coils.
  - 2. Downstream from volume dampers, turning vanes, and equipment.
  - 3. Adjacent to fire dampers, providing access to reset or reinstall fusible links.
  - 4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot (15-m) spacing.
  - 5. On sides of ducts where adequate clearance is available.
- I. Install the following sizes for duct-mounting, rectangular access doors:
  - 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
  - 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
  - 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
  - 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
  - 5. Body Access: 25 by 14 inches (635 by 355 mm).
  - 6. Body Plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- J. Install the following sizes for duct-mounting, round access doors:
  - 1. One-Hand or Inspection Access: 8 inches (200 mm) in diameter.
  - 2. Two-Hand Access: 10 inches (250 mm) in diameter.

- 3. Head and Hand Access: 12 inches (300 mm) in diameter.
- K. Label access doors according to Division 15 Section "Mechanical Identification."
- L. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- M. For fans developing static pressures of 5-inch wg (1250 Pa) and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- N. Connect terminal units to supply ducts with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.
- O. Connect diffusers to low pressure ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
- P. Connect flexible ducts to metal ducts with draw bands.
- Q. Install duct test holes where required for testing and balancing purposes.

3.02 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Adjust fire dampers for proper action.
- C. Final positioning of manual-volume dampers is specified in Division 15 Section "Testing, Adjusting, and Balancing."

END OF SECTION 15820



SECTION 15838

POWER VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

- 1. Ceiling-mounting ventilators.
- 2. In-line centrifugal fans.
- 3. Propeller fans.

1.03 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base air ratings on actual site elevations.
- B. Operating Limits: Classify according to AMCA 99.

1.04 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
  - 1. Certified fan performance curves with system operating conditions indicated.
  - 2. Certified fan sound-power ratings.
  - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - 4. Material gages and finishes, including color charts.
  - 5. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
  - 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.
- C. Coordination Drawings: Show roof penetration requirements and reflected ceiling plans drawn to scale and coordinating roof penetrations and units mounted above ceiling. Show the following:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

- D. Maintenance Data: For power ventilators to include in maintenance manuals specified in Division 1.

**1.05 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

**1.07 COORDINATION**

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

**1.08 EXTRA MATERIALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Belts: One set for each belt-driven unit.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ceiling-Mounting Ventilators:

- a. Carnes Company HVAC.
- b. Cook, Loren Company.
- c. Greenheck Fan Corp.
- d. Penn Ventilation Companies, Inc.

2. In-Line Centrifugal Fans:

- a. Carnes Company HVAC.
- b. Cook, Loren Company.
- c. Greenheck Fan Corp.
- d. Hartzell Fan, Inc.
- e. Penn Ventilation Companies, Inc.

3. Propeller Fans:

- a. Carnes Company HVAC.
- b. Cook, Loren Company.
- c. Greenheck.
- d. Hartzell Fan, Inc.
- e. Penn Ventilation Companies, Inc.

### 2.02 CEILING-MOUNTING VENTILATORS

- A. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.
- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Grille: Plastic louvered grille with flange on intake and thumbscrew attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
2. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
3. Filter: Washable aluminum to fit between fan and grille.
4. Isolation: Rubber-in-shear vibration isolators.

2.03 IN-LINE CENTRIFUGAL FANS

- A. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Driven Units: Motor encased in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- F. Accessories:
1. Companion Flanges: For inlet and outlet duct connections.
  2. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
  3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.04 PROPELLER FANS

- A. Description: Belt-driven or direct-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.
- B. Housing: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
- C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
- D. Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.



- E. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  - 1. Service Factor Based on Fan Motor: 1.4.
  - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - a. Ball-Bearing Rating Life: ABMA 9,  $L_{10}$  of 100,000 hours.
  - 4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
  - 5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - 6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - 7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- F. Accessories:
  - 1. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
  - 2. Wall Sleeve: Galvanized steel to match fan and accessory size.
  - 3. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

## 2.05 MOTORS

- A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.
- B. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B.
- C. Enclosure Type: Open dripproof.

## 2.06 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install power ventilators level and plumb.

- B. Support units using neoprene isolators. Vibration- and seismic-control devices are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
- C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and neoprene isolators. Vibration-control devices are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
  - 1. In seismic zones, restrain support units.
- F. Install units with clearances for service and maintenance.
- G. Label units according to requirements specified in Division 15 Section "Mechanical Identification."

### 3.02 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.03 FIELD QUALITY CONTROL

- A. Equipment Startup Checks:
  - 1. Verify that shipping, blocking, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 3. Verify that cleaning and adjusting are complete.
  - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - 5. Verify lubrication for bearings and other moving parts.
  - 6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

7. Disable automatic temperature-control operators.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.05 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain power ventilators.

1. Train Government's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."

3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Government, through Contracting Officer, with at least seven days' advance notice.

END OF SECTION 15838

SECTION 15840

AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:

- 1. Single-duct air terminal units

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - 1. Ceiling suspension assembly members.
  - 2. Method of attaching hangers to building structure.
  - 3. Size and location of initial access modules for acoustical tile.
  - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Closeout Procedures," include the following:
  - 1. Instructions for resetting minimum and maximum air volumes.
  - 2. Instructions for adjusting software set points.

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1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.05 COORDINATION

- A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.02 SINGLE-DUCT AIR TERMINAL UNITS

- A. Available Manufacturers:
  - 1. Anemostat; a Mestek Company.
  - 2. Carnes.
  - 3. Environmental Technologies, Inc.; Enviro-Air Div.
  - 4. Krueger.
  - 5. METALAIRE, Inc.; Metal Industries Inc.
  - 6. Nailor Industries of Texas Inc.
  - 7. Phoenix Controls Corporation.
  - 8. Price Industries.
  - 9. Titus.
  - 10. Trane Co. (The); Worldwide Applied Systems Group.
  - 11. Trox USA, Inc.
  - 12. Tuttle & Bailey.

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- B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- C. Casing: 0.034-inch (0.85-mm) steel.
  - 1. Casing Lining: 1/2-inch- (13-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive.
  - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
  - 3. Air Outlet: S-slip and drive connections.
  - 4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
  - 1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
  - 2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
- E. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F (minus 18 to plus 60 deg C); shall be impervious to moisture and fungus; shall be suitable for 10-inch wg (2500-Pa) static pressure; and shall be factory tested for leaks.
- F. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
  - 1. Maximum Damper Leakage: ARI 880 rated, 2 3 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.
  - 2. Damper Position: Normally open.
- G. Attenuator Section: 0.034-inch (0.85-mm) steel sheet metal.
  - 1. Lining: 1/2-inch- (13-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil.
- H. DDC Controls: Bidirectional damper operators and microprocessor-based controller and room sensor shall be compatible with temperature controls specified in Division 15 Section "HVAC Instrumentation and Controls" and shall have the following features:
  - 1. Damper Actuator: 24 V, powered closed, spring return open.
  - 2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
    - a. Proportional, plus integral control of room temperature.
    - b. Time-proportional reheat-coil control.
    - c. Occupied and unoccupied operating mode.
    - d. Remote reset of airflow or temperature set points.

- e. Adjusting and monitoring with portable terminal.
  - f. Communication with temperature-control system specified in Division 15 Section "HVAC Instrumentation and Controls."
3. Room Sensor: Wall mounting, with temperature set-point adjustment and access for connection of portable operator terminal.
- I. Control Sequence:
- 1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.
  - 2. Factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay.
  - 3. System-powered, wall-mounting thermostat.

## 2.03 SOURCE QUALITY CONTROL

- A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.
- B. Verification of Performance: Rate air terminal units according to ARI 880.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

### 3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air terminal units to allow service and maintenance.
- C. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- D. Connect ducts to air terminal units according to Division 15 Section "Metal Ducts."
- E. Ground units with electric heating coils according to Division 16 Section "Grounding and Bonding."
- F. Connect wiring according to Division 16 Section "Conductors and Cables."



- G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
  - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

### 3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions and do the following:
    - a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
    - b. Verify that controls and control enclosure are accessible.
    - c. Verify that control connections are complete.
    - d. Verify that nameplate and identification tag are visible.
    - e. Verify that controls respond to inputs as specified.

### 3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain air terminal units. Refer to Division I Section "Closeout Procedures."

END OF SECTION 15840



SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.
- B. Related Sections include the following:
  - 1. Division 10 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
  - 2. Division 15 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.03 SUBMITTALS

- A. Product Data: For each product indicated, include the following:
  - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - 2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - 1. Ceiling suspension assembly members.
  - 2. Method of attaching hangers to building structure.
  - 3. Size and location of initial access modules for acoustical tile.
  - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
  - 5. Duct access panels.

PART 2 - PRODUCTS

2.01 MANUFACTURED UNITS

- A. Diffusers, Registers and Grilles are scheduled on the Drawings.

2.02 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 15855

SECTION 15856

INTAKE AND RELIEF VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following types of roof-mounting intake and relief ventilators:
  - 1. Roof hoods.
- B. Related Sections include the following:
  - 1. Division 10 Section "Louvers and Vents" for ventilator assemblies provided as part of the general construction.
  - 2. Division 15 Section "Power Ventilators" for roof-mounting exhaust fans.

1.03 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Intake and relief ventilators shall be capable of withstanding the effects of gravity loads, wind loads, and thermal movements without permanent deformation of components, noise or metal fatigue, or permanent damage to fasteners and anchors.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For intake and relief ventilators. Include plans, elevations, sections, details, and ventilator attachments to curbs and curb attachments to roof structure.
- C. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - 1. Structural members to which roof curbs and ventilators will be attached.
  - 2. Sizes and locations of roof openings.
- D. Welding certificates.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain ventilators through one source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of intake and relief ventilators and are based on the specific equipment indicated. Refer to Division 1 Section "Product Requirements."

1. Do not modify intended aesthetic effects, as judged solely by Contracting Officer, except with Contracting Officer's approval. If modifications are proposed, submit comprehensive explanatory data to Contracting Officer for review.

- C. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.2, "Structural Welding Code--Aluminum."
2. AWS D1.3, "Structural Welding Code--Sheet Steel."

#### 1.06 COORDINATION

- A. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

#### 2.02 MATERIALS

- A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.
- D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
1. Use types and sizes to suit unit installation conditions.
  2. Use hex-head or Phillips pan-head screws for exposed fasteners, unless otherwise indicated.

2.03 FABRICATION, GENERAL

- A. Factory or shop fabricate intake and relief ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

2.04 ROOF HOODS

- A. Available Manufacturers:
  - 1. Carnes.
  - 2. Greenheck.
  - 3. Loren Cook Company.
  - 4. Penn Ventilation.
- B. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 5-6 and 5-7.
- C. Materials: Galvanized-steel sheet, minimum 0.064-inch- (1.62-mm-) thick base and 0.040-inch- (1.0-mm-) thick hood or aluminum sheet, minimum 0.063-inch- (1.6-mm-) thick base and 0.050-inch- (1.27-mm-) thick hood; suitably reinforced.
- D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.
  - 1. Configuration: Built-in cant and mounting flange.
  - 2. Overall Height: 12 inches (300 mm).
- E. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire or aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire.
- F. Galvanized-Steel Sheet Finish:
  - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to

- ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
2. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).
    - a. Color and Gloss: As selected by Contracting Officer from manufacturer's full range.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install intake and relief ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure intake and relief ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.
- C. Install intake and relief ventilators with clearances for service and maintenance.
- D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 7 Section "Joint Sealants" for sealants applied during installation.
- F. Label intake and relief ventilators according to requirements specified in Division 15 Section "Mechanical Identification."
- G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

#### 3.02 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories.



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3.03 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

END OF SECTION 15856



SECTION 15900

HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. Related Sections include the following:
  - 1. Division 13 Section "Fire Alarm" for smoke detectors mounted in HVAC systems and equipment.
  - 2. Division 15 Section "Sequence of Operation" for requirements that relate to this Section.

1.3 DEFINITIONS

- A. DDC: Direct-digital controls.
- B. LAN: Local area network.
- C. MS/TP: Master-slave/token-passing.
- D. PICS: Protocol Implementation Conformance Statement.

1.4 SYSTEM DESCRIPTION

- A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
- B. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems.
- C. Control system includes the following:
  - 1. Fire alarm system specified in Division 13 Section "Fire Alarm."

1.5 SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
  - 1. Each control device labeled with setting or adjustable range of control.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
  - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
  - 3. Details of control panel faces, including controls, instruments, and labeling.
  - 4. Written description of sequence of operation.
  - 5. Schedule of dampers including size, leakage, and flow characteristics.
  - 6. Schedule of valves including leakage and flow characteristics.
  - 7. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
  - 8. Listing of connected data points, including connected control unit and input device.
  - 9. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
  - 10. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- C. ASHRAE BACnet Statement: PICS for each DDC system component (panel, zone controller, field devices, and operator workstation) proposed.
- D. Samples: For each color required, of each type of thermostat cover.
- E. Software and Firmware Operational Documentation: Include the following:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
  - 3. Device address list.
  - 4. Printout of software application and graphic screens.
  - 5. Software license required by and installed for DDC workstations and control systems.
- F. Software Upgrade Kit: For Government to use in modifying software to suit future power system revisions or monitoring and control revisions.
- G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

- H. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:
  - 1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
  - 2. Interconnection wiring diagrams with identified and numbered system components and devices.
  - 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
  - 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
  - 5. Calibration records and list of set points.
- I. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- J. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

#### 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those indicated for this Project and with a record of successful in-service performance.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
- E. Comply with ASHRAE 135 for DDC system control components.
- F. Year-2000 Compliant: Computer hardware and software shall be capable of accurately processing, providing, and receiving date data from, into, and between the twentieth and twenty-first centuries, including leap-year calculations.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

#### 1.8 COORDINATION

- A. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.

- B. Coordinate equipment with Division 13 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
- D. Coordinate equipment with Division 16 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.
- E. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Control Systems Components:
    - a. Belimo Aircontrols (USA), Inc.
    - b. Honeywell, Inc.; Home & Building Control.
    - c. Johnson Controls, Inc.; Controls Group.
    - d. Landis & Staefa, Inc.
  - 2. Electronic, and DDC Systems:
    - a. Honeywell, Inc.; Home & Building Control.
    - b. Johnson Controls, Inc.; Controls Group.
    - c. Landis & Staefa, Inc.
    - d. Siebe Environmental Controls; Barber-Coleman/Robertshaw Products.
    - e. Trane Co. (The); North American Commercial Group.

### 2.2 DDC EQUIPMENT

- A. Operator Station: Microcomputer station with printer.
- B. Workstation: IBM-compatible microcomputer with minimum configuration as follows:
  - 1. Processor: Intel Pentium MMX, 200 MHz.
  - 2. Random-Access Memory: 32 MB.
  - 3. Cache Memory: 256 kB.
  - 4. Graphics: Super video graphic adapter (SVGA), minimum 1280 x 1024 pixels, 2.0-MB EDO video memory.
  - 5. Monitor: 17 inches (432 mm), noninterlaced, color, with maximum 0.28-mm dot pitch.
  - 6. Keyboard: QWERTY, 105 keys in ergonomic shape.
  - 7. Floppy-Disk Drives: 1.44 MB.
  - 8. Hard-Disk Drive: 4.0 GB.

9. CD-ROM Drive: 24x.
  10. Mouse: Three button.
  11. Modem: Autodial, internal, minimum 56 kBaud.
  12. Tape Backup: Internal Zip-drive, 100 MB.
  13. Operating System: Microsoft Windows 95 or later.
  14. BACnet Conformance: Workstation shall support BACnet device and have minimum capabilities defined in PICS for the following areas:
    - a. Network.
    - b. Functional groups.
    - c. Standard application services supported.
    - d. Standard objects supported.
- C. Printer: Color, ink-jet type as follows:
1. Print Head: 1440 x 1440 dpi photoquality color resolution.
  2. Internal Memory Buffer: 32 kB.
  3. Paper Handling: Minimum of 100 sheets.
  4. Print Speed: Minimum of 8 ppm in black and 4 ppm in color.
- D. Application Software: Include the following:
1. Input/output capability from operator station.
  2. Operator system access levels via software password.
  3. Database creation and support.
  4. Dynamic color graphic displays.
  5. Alarm processing.
  6. Event processing.
  7. Automatic restart of field equipment on restoration of power.
  8. Data collection.
  9. Graphic development on workstation.
  10. Maintenance management.
- E. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
1. Units monitor or control each input/output point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator station.
  2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - a. Global communications.
    - b. Discrete/digital, analog, and pulse input/output.
    - c. Monitoring, controlling, or addressing data points.
    - d. Testing and developing control algorithms without disrupting field hardware and controlled environment.

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3. Local operator interface provides for download from or upload to mobile operator station.
  4. BACnet Conformance: Reside on BACnet LAN in Ethernet IEEE 802.3, Class 3, minimum, with routers between LAN and other panels, with at least one communication port, and have minimum capabilities defined in PICS for the following areas:
    - a. Network.
    - b. Functional groups.
    - c. Standard application services supported.
    - d. Standard objects supported.
- F. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
1. Units monitor or control each input/output point; process information; and download from or upload to operator station.
  2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - a. Global communications.
    - b. Discrete/digital, analog, and pulse input/output.
    - c. Monitoring, controlling, or addressing data points.
  3. Local operator interface provides for download from or upload to mobile operator station.
  4. BACnet Conformance: Reside on BACnet LAN using MS/TP, Class 2, minimum, with at least one communication port, and have minimum capabilities defined in PICS for the following areas:
    - a. Network.
    - b. Functional groups.
    - c. Standard application services supported.
    - d. Standard objects supported.
- G. LANs: Capacity for a minimum of 10 workstations connected to multiuser, multitasking environment with concurrent capability to access DDC network or control units.
1. Media: Ethernet, peer-to-peer CMA/CD, operating at 10 MBps.
- H. Software: Update to latest version of software at Project completion. Include and implement the following capabilities from the control units:
1. Units of Measure: Inch-pound and SI (metric).
  2. Load Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, DDC with fine tuning, and trend logging.
  3. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
  4. Chiller Control Programs: Control function of chilled-water reset, and equipment sequencing.
  5. Programming Application Features: Include trend point, alarm messages, weekly scheduling, and interlocking.



## 2.3 CONTROL PANELS

- A. Central (Master) Control Panels: Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide multicolor graphic displays, schematically showing system being controlled.
- B. Local Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.
  - 1. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.
  - 2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
  - 3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
  - 4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.
- C. Alarm Panels: Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted in hinged-cover enclosure.
  - 1. Alarm Condition: Indicating light flashes and horn sounds.
  - 2. Acknowledge Switch: Horn is silent and indicating light is steady.
  - 3. Second Alarm: Horn sounds and indicating light is steady.
  - 4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
  - 5. Contacts in alarm panel allow remote monitoring by independent alarm company.

## 2.4 TIME CLOCKS

- A. Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.

## 2.5 SENSORS

- A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
  - 1. Resistance Temperature Detectors: Platinum.
    - a. Accuracy: Plus or minus 0.2 percent at calibration point.
    - b. Wire: Twisted, shielded-pair cable.
    - c. Insertion Elements in Ducts: Use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (1 sq. m).

- d. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required.
  - e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
  - f. Room Sensors: Match room thermostats, locking cover.
  - g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
- a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
  - b. Output: 4 to 20 mA.
  - c. Building Static-Pressure Range: 0 to 0.25 inch wg (0 to 62 Pa).
  - d. Duct Static-Pressure Range: 0 to 5 inches wg (0 to 1243 Pa).
3. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- B. Equipment operation sensors as follows:
- 1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg (0 to 1243 Pa).
  - 2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa).
  - 3. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
- C. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- D. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vaporproof type.
- E. Carbon-Monoxide Detectors: Single or multichannel, dual-level detectors, using solid-state sensors with 3-year minimum life, maximum 15-minute sensor replacement, suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C), calibrated for 50 and 100 ppm, with maximum 120-second response time to 100-ppm carbon monoxide.
- F. Carbon-Dioxide Sensor and Transmitter: Single detectors, using solid-state infrared sensors, suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C), calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output, and wall mounted.
- G. Oxygen Sensor and Transmitter: Single detectors, using solid-state zircon cell sensing, suitable over a temperature range of minus 32 to plus 1100 deg F (0 to 593 deg C), calibrated for 0 to 5 percent, with continuous or averaged reading, 4 to 20 mA output, and wall mounted.

- H. Refrigerant Detectors: Dual-level detectors, using solid-state sensors, with alarm preset for 300 ppm, alarm indicator light, alarm silence light and button, alarm test light and button, and trouble light. Provide auxiliary relay preset for 150 ppm.
- I. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment, for flush mounting.

## 2.6 THERMOSTATS

- A. Electric solid-state, microcomputer-based room thermostat with remote sensor.
  - 1. Automatic switching from heating to cooling.
  - 2. Preferential rate control to minimize overshoot and deviation from set point.
  - 3. Set up for four separate temperatures per day.
  - 4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
  - 5. Short-cycle protection.
  - 6. Programming based on every day of week.
  - 7. Selection features include deg F or deg C display, 12- or 24-hour clock, keyboard disable, remote sensor, fan on-auto.
  - 8. Battery replacement without program loss.
  - 9. Thermostat display features include the following:
    - a. Time of day.
    - b. Actual room temperature.
    - c. Programmed temperature.
    - d. Programmed time.
    - e. Duration of timed override.
    - f. Day of week.
    - g. System mode indications include "heating," "off," "fan auto," and "fan on."
- B. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater.
- C. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, integral manual on-off-auto selector switch.
  - 1. Equip thermostats, which control electric heating loads directly, with off position on dial wired to break ungrounded conductors.
  - 2. Dead Band: Maximum 2 deg F (1 deg C).
- D. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature, with copper capillary and bulb, unless otherwise indicated.
  - 1. Bulbs in water lines with separate wells of same material as bulb.
  - 2. Bulbs in air ducts with flanges and shields.
  - 3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit, adequately supported.

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4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
  5. On-Off Thermostat: With precision snap switches, with electrical ratings required by application.
  6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
- E. Room Thermostat Cover Construction: Manufacturer's standard locking covers.
1. Set-Point Adjustment: Concealed.
  2. Set-Point Indication: Concealed.
  3. Thermometer: Concealed.
  4. Color: <Insert color from manufacturer's standard colors>.
  5. Orientation: Vertical.
- F. Room thermostat accessories include the following:
1. Insulating Bases: For thermostats located on exterior walls.
  2. Thermostat Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.
  3. Adjusting Key: As required for calibration and cover screws.
  4. Aspirating Boxes: For flush-mounted aspirating thermostats.
  5. Set-Point Adjustment: 1/2-inch- (13-mm-) diameter, adjustment knob.
- G. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
- H. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.
1. Bulb Length: Minimum 20 feet (6 m).
  2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.
- I. Electric High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.
1. Bulb Length: Minimum 20 feet (6 m).
  2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.
- J. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig (172 kPa), and cast housing with position indicator and adjusting knob.

## 2.7 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

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1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
2. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
3. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Valves: Size for torque required for valve close-off at maximum pump differential pressure.
2. Dampers: Size for running torque calculated as follows:
  - a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. (86.8 kg-cm/sq. m) of damper.
  - b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. (62 kg-cm/sq. m) of damper.
  - c. Dampers with 2 to 3 Inches wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 FPM (5 to 13 m/s): Multiply the minimum full-stroke cycles above by 1.5.
  - d. Dampers with 3 to 4 Inches wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 FPM (13 to 15 m/s): Multiply the minimum full-stroke cycles above by 2.0.
3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
6. Power Requirements (Two-Position Spring Return): 24-V ac.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
9. Temperature Rating: Minus 22 to plus 122 deg F (minus 30 to plus 50 deg C) 40 to 104 deg F (4 to 40 deg C).
10. Run Time: 12 seconds open, 5 seconds closed.

## 2.8 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

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- B. Globe Valves NPS 2 (DN 50) and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
- C. Globe Valves NPS 2-1/2 (DN 65) and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
- D. Hydronic system globe valves shall have the following characteristics:
  - 1. Rating: Class 125 for service at 125 psig (862 kPa) and 250 deg F (121 deg C) operating conditions.
  - 2. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
    - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
    - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
  - 3. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate.
  - 4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.
- E. Butterfly Valves: 200-psig (1380-kPa), 150-psig (1035-kPa) maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
  - 1. Body Style: Wafer or Lug.
  - 2. Disc Type: Aluminum bronze.
  - 3. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.
- F. Terminal Unit Control Valves: Bronze body, bronze trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.
  - 1. Rating: Class 125 for service at 125 psig (862 kPa) and 250 deg F (121 deg C) operating conditions.
  - 2. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.
  - 3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

## 2.9 DAMPERS

- A. Dampers: AMCA-rated, parallel or opposed-blade design; 0.1084-inch (2.8-mm) minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635-inch (1.6-mm) galvanized steel with maximum blade width of 8 inches (203 mm).
  - 1. Blades shall be secured to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel

- and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
  3. For standard applications, include optional closed-cell neoprene edging.
  4. For low-leakage applications, use parallel- or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 4 inches wg (995 Pa) when damper is being held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

#### 3.2 INSTALLATION

- A. Install equipment level and plumb.
- B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- C. Connect and configure equipment and software to achieve sequence of operation specified.
- D. Verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate all 60 inches (1524 mm) above the floor.
  1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- E. Install guards on thermostats.
- F. Install automatic dampers according to Division 15 Section "Duct Accessories."
- G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- H. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."
- I. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."

- J. Install refrigerant instrument wells, valves, and other accessories according to Division 15 Section "Refrigerant Piping."
- K. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.
- L. Install electronic and fiber-optic cables according to Division 16 Section "Control/Signal Transmission Media."

### 3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 16 requirements.
- B. Install building wire and cable according to Division 16 requirements.
- C. Install signal and communication cable according to Division 16 requirements.
  - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
  - 2. Install exposed cable in raceway.
  - 3. Install concealed cable in raceway.
  - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
  - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
  - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

### 3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
  - 1. Install piping adjacent to machine to allow service and maintenance.
- B. Ground equipment.
  - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.



### 3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
  - 3. Calibration test electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
- B. Engage a factory-authorized service representative to perform startup service.
- C. Replace damaged or malfunctioning controls and equipment.
  - 1. Start, test, and adjust control systems.
  - 2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
  - 3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
- D. Verify DDC as follows:
  - 1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
  - 2. Verify operation of operator workstation.
  - 3. Verify local control units including self-diagnostics.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain control systems and components.
  - 1. Train Government's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
  - 2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.
  - 3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
  - 4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
  - 5. Schedule training with Government, through Contracting Officer, with at least seven days' advance notice.

3.7 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Government, to adjust and calibrate components and to assist Government's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION 15900

SECTION 15940

SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. See Division 15 Section "HVAC Instrumentation and Controls" for control equipment and devices and submittal requirements.

1.02 SUBMITTALS

- A. Shop Drawings: Written descriptions and diagrams of operational sequences.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 COOLING SYSTEM

- A. Air Cooled Chiller (CH-1) and Pump (CHWP-1):
  - 1. The BAS shall enable the chilled water system to operate based upon time of day schedule and whenever the outside air temperature is above 65°F (adjustable).
  - 2. The chilled water pump (CHWP-1) shall be energized and run continuously.
  - 3. Once flow has been proven through the evaporator, the chiller (CH-1) shall be enabled to operate.
  - 4. The manufacturer's standalone microprocessor based control panel shall monitor and control chiller operation to maintain a CHWS temperature of 44°F (adjustable).
  - 5. In the event of loss of flow, an alarm signal shall be provided to the BAS.
  - 6. In the event of chiller failure or shutdown, a common alarm signal shall be provided to the BAS.
  - 7. Start/stop status signals shall also be provided to the BAS.

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### 3.02 HEATING SYSTEM

#### A. Lead/Lag HW Pumps (HWP-1, 2):

1. Whenever the outside air temperature is below 55°F (adjustable), the lead hot water pump shall be energized and run continuously. Pump speed shall be controlled by its respective VFD to maintain constant differential pressure.
2. If the lead pump fails to operate, the lag pump shall be energized and an alarm signal shall be provided to the BAS.
3. Lead/lag pump status shall be rotated on a monthly basis for even wear.
4. Start/stop status signals shall also be provided to the BAS.

#### B. HW Boilers (B-1, 2, 3):

1. Once hot water flow has been proven in the primary loop, the boilers shall be enabled to operate via the manufacturer's sequencing/control panel.
2. The panel shall assign each boiler "Lead", "Lag", or "Standby" status. Boiler status shall be rotated on a monthly basis for even wear.
3. The panel shall operate each boiler and its respective pump (i.e., B-1/P-1, B-2/P-2, B-3/P-3) as necessary to maintain desired HWS temperature.
4. HWS temperature shall be reset as follows:

<u>HWS Temperature</u>	<u>OA Temperature</u>
180°F	15°F
160°F	55°F

5. In the event of boiler and/or pump failure, a common alarm signal shall be provided to the BAS.
6. Start/stop status signals shall also be provided to the BAS.

#### C. Unit Heaters:

1. On a call for heat, the fan shall be energized.
2. When the thermostat is satisfied, the fan shall be deenergized.
3. An aquastat shall prevent fan operation if the HWS temperature is below 80°F (adjustable).

D. Cabinet Unit Heaters:

1. On a call for heat, the fan shall be energized and the hot water control valve shall modulate open to maintain desired space temperature setpoint.
2. When the thermostat is satisfied, the fan shall be de-energized and the control valve shall close.
3. An aquastat shall prevent fan operation if the HWS temperature is below 80°F (adjustable).

E. Gas-Fired Radiant Heaters (RH-1 thru 11):

1. On a call for heating, either the programmable thermostat (RH-1 thru 4) or thermostat (RH-5 thru 11) shall energize the burner and exhaust fan.
2. The heater shall run continuously to maintain space temperature setpoint.
3. An alarm signal shall be provided to the BAS for space low temperature condition.

F. Gas-Fired Unit Heater (GUH-1):

1. On a call for heat, the thermostat shall energize the burner and supply fan.
2. The heater shall run continuously to maintain space temperature setpoint. The supply fan shall continue to run for 30 seconds (adjustable) after burner shutoff.
3. An alarm signal shall be provided to the BAS for space low temperature condition.

G. Hot Water Coils (HWC-1, 2):

1. The control valve shall modulate to maintain desired space temperature setpoint.

H. HW Make-up Air Unit (MAU-1):

1. MAU-1 shall be interlocked with Kitchen Hood Exhaust Fan (EF-2).
2. The face and bypass dampers shall modulate to maintain a duct supply air temperature of 65°F (adjustable).
3. In the event of MAU failure or low supply air temperature, an alarm signal shall be provided to the BAS.
4. Start/stop status signals shall also be provided to the BAS.

I. Gas-Fired Make-up Air Unit (MAU-2):

1. MAU-2 unit fan shall be energized based on time of day schedule. EF-13 shall be interlocked with MAU-2.

2. Burner and supply fan shall be energized to maintain a duct supply air temperature of 60°F (adjustable).
3. In the event of MAU-2 or EF-13 failure or low supply air temperature, an alarm signal shall be provided to the BAS.
4. Start/stop status signals shall also be provided to the BAS.

J. Electric Baseboard:

1. On a call for heating, the thermostat shall energize the heating elements to maintain desired space temperature setpoint.

3.03 AIR HANDLING SYSTEMS

A. Air Handling Units (AHU-1, 2):

1. Summer Occupied Mode:

- a. The unit SF and associated RF shall run continuously. SF speed shall be controlled by its respective VFD to maintain desired static pressure in the supply duct. RF speed shall be biased to deliver 90% (adjustable) SF flow.
- b. The OA damper shall go to its minimum position.
- c. The chilled water control valve shall modulate to maintain a supply air temperature of 55°F (adjustable).
- d. In the event of fan(s) failure or high SAT, an alarm signal shall be provided to the BAS.

2. Summer Unoccupied Mode:

- a. The unit SF and associated RF shall be deenergized.
- b. The OA damper shall remain closed.

3. Winter Occupied Mode:

- a. The unit SF and associated RF shall run continuously. SF speed shall be controlled by its respective VFD to maintain desired static pressure in the supply duct. RF speed shall be biased to deliver 90% (adjustable) SF flow.
- b. The OA damper shall go to its minimum position.
- c. The hot water control valve shall modulate to maintain a supply air temperature as follows:

SAT

OAT

55°F

55°F and above

60°F

15°F

4. Winter Unoccupied Mode:
  - a. The unit SF and associated RF shall be deenergized.
  - b. The OA damper shall remain closed.
  - c. If any of the space temperature sensors drop to 55°F (adjustable), the SF and associated RF shall be energized, the OA damper shall remain closed, and the hot water control valve shall modulate to maintain SAT in accordance with the reset schedule. Fans shall continue to run until all zones are above 65°F (adjustable).
5. Morning Warm-up Mode:
  - a. Unit SF and associated RF shall be energized and the OA damper shall remain closed.
  - b. Fans shall run at 100% speed and VAV terminal units shall be fully open.
  - c. The HW control valve shall modulate to maintain a SAT of 85°F (adjustable).
  - d. Fans shall run until all zones reach 65°F (adjustable).
  - e. At completion of Morning Warm-up Mode, unit shall go into Winter Occupied Mode.
6. Economizer Mode:
  - a. The BAS shall determine when outside air is suitable for cooling based upon OA temperature and enthalpy.
  - b. The RA and OA dampers shall modulate as necessary to maintain SAT.
  - c. When OA temperature rises beyond the free cooling range, the unit shall go into the Summer Occupied Mode.
7. Alarms signals to BAS:
  - a. SF or RF failure.
  - b. High filter pressure drop.
  - c. High SAT in heating or cooling mode.
  - d. Low SAT in heating or cooling mode.

- e. Smoke detection.
- 8. Start/stop status signals shall also be provided to the BAS.
- 9. Carbon Dioxide (CO<sub>2</sub>) Override
  - a. The CO<sub>2</sub> sensor in the RA duct shall override the OA minimum damper position when the CO<sub>2</sub> levels rise above 500 PPM (adjustable).
- B. Air Handling Units (AH-1, 2):
  - 1. The supply fan shall run continuously.
  - 2. The OA damper shall be preset to its minimum position.
  - 3. Upon a call for cooling, the Remote Condensing Unit (RCU-1, 2) shall be energized to maintain space cooling setpoint. RCU shall be locked out during heating.
  - 4. Upon a call for heating, the duct-mounted hot water coil (HWC-1, 2) control valve shall modulate to maintain space heating setpoint. RCU shall be locked out during heating.
  - 5. In the event of unit failure, high or low space temperature or carbon monoxide (CO) detection (AH-2 only), an alarm signal shall be provided to the BAS.
  - 6. Start/stop status signals shall also be provided to the BAS.
- C. VAV Terminal Units (VAV):
  - 1. On a rise in space temperature above the cooling setpoint, the VAV terminal unit shall modulate to its maximum CFM.
  - 2. On a drop in space temperature below the cooling setpoint, the VAV terminal unit shall modulate to its minimum CFM.
  - 3. As the space temperature continues to fall to the heating setpoint, the VAV terminal unit shall modulate to its heating CFM. At that point, the heating control valve shall modulate open to maintain space temperature setpoint.
  - 4. During Morning Warm-up Mode, the VAV terminal units shall go to the 100% open position.
  - 5. CFM signals shall be provided to the BAS.
- D. Exhaust Fans:
  - 1. EF-1 thru EF-7 shall be energized on a preset schedule. A manual start override shall be provided.
  - 2. EF-8 thru 12, 14, 15 and 16 shall be energized on a call for cooling.



3. EF-17 shall be operated via a wall switch.
4. In the event that EF-1, 2 or 13 fail to run, an alarm signal shall be provided to the BAS.
5. All motorized dampers shall open first prior to fan starting.
6. Start/stop status signals shall also be provided to the BAS.

**E. Fan Coil Units (FCU-1 thru 6):**

1. Summer Occupied Mode:
  - a. The unit fan shall run continuously. Fan speed may be controlled by a factory-furnished speedswitch.
  - b. The OA damper shall open.
  - c. The chilled water control valve shall modulate to maintain space temperature setpoint.
2. Summer Unoccupied Mode:
  - a. The unit shall be deenergized and the OA damper shall close.
  - b. FCU-2 and 5 shall be energized subject to a CO sensor override.
3. Winter Occupied Mode:
  - a. The unit fan shall run continuously. Fan speed may be controlled by a factory-furnished speedswitch.
  - b. The OA damper shall open.
  - c. The hot water control valve shall modulate to maintain space temperature setpoint.
4. Winter Unoccupied Mode:
  - a. The unit shall be deenergized and the OA damper shall close.
  - b. FCU-2 and 5 shall be energized subject to a CO sensor override.
  - c. The unit fan shall cycle and the hot water control valve shall modulate to maintain night setback temperature.
5. Alarm signals to B.A.S.
  - a. Unit failure.
  - b. High filter pressure drop.

- c. High or low space temperature.
- d. Carbon Monoxide (CO) (FCU-2 and 5 only).
- 6. Start/stop status signals shall also be provided to the BAS.

**3.04 MISCELLANEOUS**

**A. Heat Recovery System:**

- 1. Heat recovery pump HRP-1 shall be interlocked to operate whenever MAU-2/EF-13 are energized and when the OA temperature is below 55°F (adjustable).
- 2. Heat recovery pump HRP-2 shall be interlocked to operate whenever AHU-1/EF-1 are energized.
- 3. The 3-way mixing valve shall modulate as necessary to prevent the EWT to the HRC in the exhaust duct from dropping below 20°F (adjustable).
- 4. Start/stop status signals shall also be provided to the BAS.

END OF SECTION 15940